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Larval Development in *Bufo woodhousei fowleri* and *Scaphiopus holbrooki holbrooki*

KENNETH L. GOSNER AND IRVING H. BLACK

THE difficulty in identifying anuran larvae has restricted the use of such material in distributional and ecological investigations. Detailed analyses of variation in diagnostic characters have not been made for most species. Published descriptions are usually of mature tadpoles, and give little information on developmental changes from hatching to transformation. A preliminary study of these problems in *Bufo w. fowleri* and *Scaphiopus h. holbrooki* is here presented. The study is based on New Jersey material preserved in the Newark Museum.

**DISTRIBUTION AND BREEDING SEASONS.**—*Scaphiopus h. holbrooki* occurs in more or less isolated colonies in the New Jersey Coastal Plain. Our collections contain specimens from Monmouth County (Eatontown); Ocean County (south of Hornerstown, Monmouth County); Cumberland County (SW of Belle-Plain Forest, and Dorchester); Cape May County (Bennett and Rio Grande); and Gloucester County (Bluebell).

*Bufo w. fowleri* is apparently common throughout the state, but is especially abundant on the Coastal Plain. Natural *B. w. fowleri* × *B. t. americanus* hybridization has been described in Bergen County populations by Blair (1947) and Volpe (1952). We have found apparently similar situations at Green Village, Morris County and at Swartwood Lake, Sussex County, and suggest that a zone of hybridization between these forms may extend across the northern part of New Jersey. We have heard "good" *t. americanus* choruses in Passaic, Morris, Sussex, and Warren counties, all north and west of the Fall Line. Except for small series from Morris and Warren counties, whose hybrid status might be questioned, our *Bufo* material is from Coastal Plain localities and is presumably typical *w. fowleri*. We have made no attempt, as yet, to separate larvae of the two toads in this area.

*Scaphiopus h. holbrooki* usually breeds during periods of 2 to 3 days, its reproductive activi-

ties being in large part rain-initiated. Comparative absence of temperature control in the initiation of breeding activity results in an extended breeding season, beginning in New Jersey as early as the third week of March and extending into August. *B. w. fowleri* also has a protracted breeding season that is modified by rainfall, at least on the Coastal Plain. Activity in *w. fowleri* begins in mid-May in central New Jersey (Monmouth County) and continues into August. The reproductive activities of *t. americanus* do not appear to be protracted, as are those of *w. fowleri*, and are presumably temperature controlled. It breeds at the beginning of April, and good choruses appear to be maintained for only a short period. In central and southern New Jersey larvae of *h. holbrooki* and *w. fowleri*, in various stages of development, may be found or expected during the late spring and summer months. Newly hatched *w. fowleri* may be found concurrently with mature or transforming specimens.

**MATERIALS.**—The following larvae were examined: 228 *Bufo w. fowleri*, representing 15 series from eight different localities (in Atlantic, Cape May, Monmouth, Warren, and Morris counties), and 260 *Scaphiopus h. holbrooki*, representing 14 series from five localities (in Monmouth, Ocean, Gloucester, and Cape May counties). These represent various stages of development from hatching to transformation. Preliminary comparisons have been made with local ranid and hylid species to check the validity of family characters. This material includes field collections, as well as developmental series reared from eggs laid by frogs taken in amplexus, or mated in the laboratory.

Larger larvae were measured with a pair of fine-pointed dividers, and the early stages with a low power microscope, fitted with an eyepiece micrometer disc.

Staging of embryos and larvae in metamorphosis is figured for *Rana pipiens* in Rugh (1951), and in this paper we follow this procedure in designating embryonic stages by

Arabic and larval stages by Roman numerals. Although not strictly comparable, they provide a useful approximation to staging in *Bufo* and *Scaphiopus*. Stebbens (1951) figured the structural characteristics of larvae with the terminology used in their description.

**DIAGNOSTIC CHARACTERS FOR EARLY LARVAE.**—In the early hatchlings (embryonic stages 20–25) relative size, pigmentation, and form of adhesive organs provide a reliable means of differentiating between *Bufo w. fowleri* and *Scaphiopus h. holbrooki* and equivalent stages in other families.

Color differences used for diagnostic purposes are not reliable if based on soluble pigments and structural colors (iridescence), since these characters disappear within a short time after preservation. The relatively insoluble melanin pigments are much more stable.

*Bufo w. fowleri* hatchlings may be distinguished from those of local *Scaphiopus* and Ranidae on the basis of size. At Stage 20 the toads are approximately 4.22 mm. in total length, while *Scaphiopus* hatchlings are about 5.73 mm. and those of the local ranids range from about 6 mm. to 7 mm. In all three groups the early larvae are very darkly pigmented, except for *Rana palustris*, which are creamy white to a pale chocolate brown. Like *R. palustris*, the local hylid hatchlings are sharply differentiated from the toads and ranids by their pale coloration. Local hylids vary in size at Stage 20 from about 4.21 mm. in *Hyla crucifer* to about 5 mm. in *H. versicolor*. The operculum is closed (Stage 25) in *w. fowleri* by the time the larva reaches about 6 mm. (the Stage 20 size for ranids). *H. crucifer* is more or less equivalent to Fowler's toad in hatchling size, but at Stage 25 the larva is considerably larger, being about 7.75 mm. long. The ranids, examined at Stage 25, ranged from about 7.70 mm. in *R. clamitans* to 12 mm. or more in *R. sylvatica*.

*Scaphiopus h. holbrooki* hatchlings may be immediately recognized by the form of the adhesive organ. It is a strong V-shaped structure at Stage 20 (Fig. 1). The adhesive organ of *w. fowleri* is broadly U-shaped at Stage 20 but by Stage 23 the central, deeper portion has deteriorated, leaving two small suckers lateral to and somewhat behind the oral disc. The presumably more primitive, crescent-shaped form of the adhesive organ (Noble and

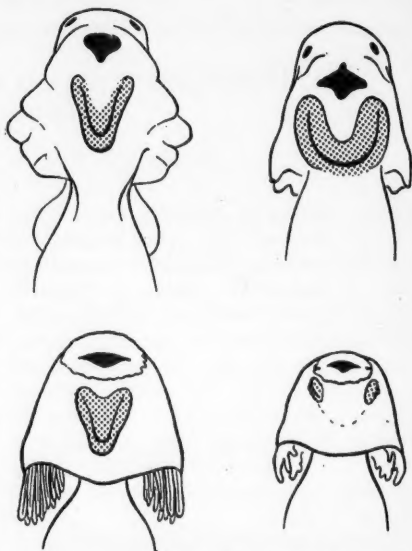


Fig. 1. Very early larvae of *Scaphiopus h. holbrooki* (upper left: Stage 20, 5.73 mm.; lower left: Stage 23, 7.75 mm.) and *Bufo w. fowleri* (upper right: Stage 20, 4.22 mm.; lower right: Stage 23, 5.19 mm.).

Noble, 1923) occurs in the late embryonic stages of some local hylid larvae, but the suckers in these are bifid at hatching. *B. w. fowleri* appears to preserve the primitive condition to a somewhat later stage than the hylids do. In local ranids the suckers are also bifid at hatching. *S. h. holbrooki* retains the crescent-shaped form throughout its early larval stages. A sucker scar persists for a considerable period as a V- or Y-shaped concentration of dark pigment on the otherwise sparsely pigmented ventral surface. In a few individuals it may still be detected when the total length is 18 or 19 mm. The equivalent scars deteriorate very rapidly in *w. fowleri*. In most of our materials they could not be detected in larvae longer than 8 to 9 mm.

**DIAGNOSTIC CHARACTERS FOR LATER LARVAE.**—In later larvae from the completion of the operculum to transformation, relative size (correlated with staging), oral disc structure, and labial tooth formulae, together with details of pigmentation, are useful for identification purposes. Coincident with the closing of the operculum the oral disc assumes its characteristic form.



Apparently reliable characters for family determination concern the extent of the papillary border (Wright, in key, 1949). In *h. holbrooki* the papillae completely encircle the oral disc with the usual exception of a very short space above the abbreviated top row of labial teeth. The disc is not emarginate (indented). In local ranids and hylids the papillary border extends across the lower margin (with the exception of a short gap below the third, lower, labial tooth-row in most *H. crucifer*) but there is a wide space, free of papillae, across the upper labium. The disc is emarginate in ranids; not emarginate in hylids. In *w. fowleri* the papillae are present laterally, but there are wide spaces without papillae on both the upper and lower labia. The disc is emarginate. These characters are clearly defined in toad larvae measuring 6 mm. and longer.

At this time, also, the labial teeth appear well formed, darkly pigmented, and represent the mature formula, 2/3. In the entire series of *w. fowleri* examined, we found no departure from this formula except occasionally in mutilated individuals. Pigmented labial teeth do not appear in specimens of *h. holbrooki* smaller than 9.5 mm. At this size three lower rows are slightly pigmented, and the presence of three upper rows is indicated by a series of pronounced ridges lacking pigmented teeth (Fig. 2). Development of tooth rows in *h. holbrooki* is gradual and is subject to individual variation. Increase in total length may, however, be correlated with an increase in the number of tooth rows. Wright (*op. cit.*) figured the mature mouth parts of *h. holbrooki* and *w. fowleri*.

**DETAILS OF COLORATION.**—In life the tadpoles of *h. holbrooki* are dark brown, finely suffused with a golden iridescence, which forms a prominent longitudinal stripe on the dorsal ridge of the tail musculature. The tadpole remains more or less transparent ventrally throughout the larval period. *B. w. fowleri* larvae are sooty black in life. The tail musculature is sharply bicolor, with about 60 to 80 percent of the dorso-lateral surface evenly colored with black. The remaining ventral border is usually immaculate. The tail musculature of *h. holbrooki* is indistinctly bicolored, downward suffusions of pigment giving the ventro-lateral surface a dirty appearance.

**SIZE AND STAGING OF LARVAE.**—Variations

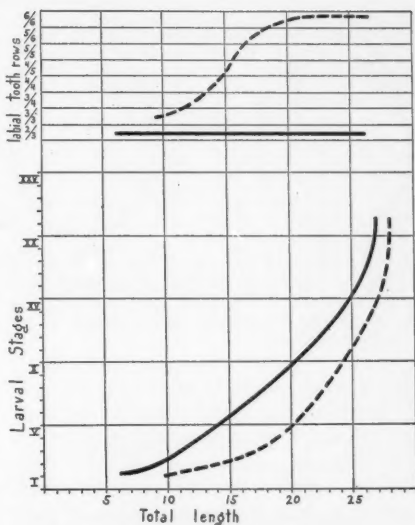


Fig. 2. Relationship of labial tooth rows (upper) and larval stages (lower) to total length (in mm.). Solid line, *Bufo w. fowleri*; broken line, *Scaphiopus h. holbrooki*.

from the indicated curve for *w. fowleri* suggest the possibility of seasonal differences in total length attained, but may represent merely individual or local variations. There is a great deal of variation in *h. holbrooki* in size-staging relationships, and the curve given is approximate (Fig. 2). Wright (*op. cit.*) gave 27 mm. for *w. fowleri* and 28 mm. for *h. holbrooki* at full growth. Our *w. fowleri* at full growth (larval Stage XIX) range from 21.6 mm. to 30.2 mm. with an average of about 26 mm. Our maximum length for *h. holbrooki* is 46.5 mm. Our smallest Stage-XIX specimen is 24.1 mm. The mature larva of *h. holbrooki* has a broadly rounded form in dorsal aspect; the eyes are very small, and the spiracle is located well below the lateral body axis. *B. w. fowleri* has the spiracle located on the lateral body axis; its eyes are proportionately larger, and the greatest body width is at a point farther back (Fig. 3).

During 1952, an unusual situation developed in the colony at Eatontown. A series of 54 larvae collected on May 12 averaged 37.2 mm. total length (mode 44 mm.), and one of 117 specimens collected on May 6 averaged 39.6 mm. (mode 42 mm.). These were field collections, but a similar situation developed in one of our 1952 laboratory groups. Trowbridge

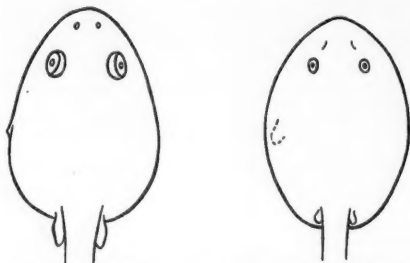


Fig. 3. Mature larvae of *Bufo w. fowleri* (left) and *Scaphiopus h. holbrookii* (right), dorsal aspect. In *Scaphiopus* the spiracle (dashed outline) is not visible from above.

and Trowbridge (1937) mentioned larvae of *S. bombifrons* that reached two or three times average size. Their specimens were apparently abnormal and suffered high mortality. The authors suggested that this excessive growth may have resulted from the absence of plant food in the early stages of development of a laboratory-reared group. We reared a number of *h. holbrookii* broods during 1951 and 1952 on a strict meat diet. No plant food was provided, apart from whatever microscopic vegetation may have been attached to field-collected egg masses. The frequency of runts, other abnormalities, or general mortality did not appear unusually high, and a large proportion of our materials passed through transformation successfully. Except for the single outsized group, our broods reached full growth at 28 to 30 mm. We have no explanation for the excessive growth in the unusual 1952 broods.

**TRANSFORMATION.**—Shortly before the protrusion of the front limbs, other changes associated with transformation begin to appear. These affect the shape, coloration, mouth parts, and proportions of the larvae. The diagnostic characters of the oral disc remain fairly well defined until after the front legs appear, when a shrinkage of the tail, together with other pronounced changes, proceeds very rapidly. In *w. fowleri* the skin becomes quite warty and color changes produce a simplified pattern resembling that of the adult. Skin texture in *h. holbrookii* also changes, and when the young leave the water the pattern is essentially that of the adult, with the dorso-lateral golden stripes distinctly formed. The metatarsal tubercles (metacarpal in *w. fowleri*) are well

developed; they are pigmented in *w. fowleri* but unpigmented in *h. holbrookii*. In general appearance the newly transformed young are miniature replicas of the adults, and consequently may be readily identified. Transformation sizes given by Wright (*op. cit.*) are: *w. fowleri*, 7.5 to 11.5 mm., and *h. holbrookii*, 8.5 to 12 mm.

**SUMMARY.**—The following key is a résumé of the characters used to identify *S. h. holbrookii*, *B. w. fowleri*, and other larvae of the New Jersey area.

#### I. At Hatching

##### A. Size small, about 4.2 to 5 mm.

Dark, with a U-shaped adhesive organ in Stage 20, bifid at Stage 23 and later  
..... *Bufo w. fowleri*.

Very pale with bifid adhesive organs at Stage 20 and later..... *Hylidae*.

##### B. Size larger, about 5.73 to 7 mm.

Very pale with bifid adhesive organs at Stage 20 and later..... *Rana palustris*.

Very dark

With V-shaped adhesive organ in Stage 20 through Stage 25..... *Scaphiopus h. holbrookii*.

With adhesive organs bifid in Stages 20 through 25..... other *Ranidae*.

#### II. After Stage 25

A. Papillary border completely encircling oral disc, except for a very short gap (without papillae) on upper labium; not emarginate. V- or Y-shaped adhesive organ scar persisting to about 15 mm. total length; labial teeth 4/5 to 5/5 at 15 mm. total length, usually 5/5 to 6/6 at 20 mm. or larger; eyes very small; spiracle well below the lateral body axis  
..... *Scaphiopus h. holbrookii*.

B. Papillary border with a broad gap (without papillae) on both the upper and lower labia, border emarginate; tadpole very dark; tail musculature sharply bicolor; spiracle on lateral body axis; labial teeth 2/3..... *Bufo w. fowleri*.

C. Papillary border with a broad gap on the upper labium only (in some *H. crucifer* a very short gap on lower labium also)

Papillary border emarginate..... *Ranidae*.

Papillary border not emarginate..... *Hylidae*.

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NEWARK MUSEUM, 43 WASHINGTON ST., NEWARK, NEW JERSEY.

## Variations in the Rows of Labial Teeth in Tadpoles

JACK BRESLER AND ARTHUR N. BRAGG

WHILE the utilization for taxonomic purposes of the larval mouth-part characteristics of salientian tadpoles has been long recognized, the seemingly unlimited structural variations encountered in labial papillae, mandibles, labial teeth, etc., often present a confusing picture. Quantitative studies of any one of the labial characteristics can materially contribute to the alleviation of many uncertainties in identification of various species. This study is concerned exclusively with one such characteristic, the number of rows of tadpole labial teeth in five salientian species, from individuals collected in Oklahoma.

Bragg's names of species and subspecies, and definitions of mouth parts (1950), are used throughout this paper.

The definitive morphological characteristics which make up a row of teeth are not clearly delimited in the literature. Accordingly, a row of teeth was taken to mean a series of at least three distinctly pigmented epithelial tubercles on either side of a labium (Fig. 1). Little diffi-

culty was encountered with the use of this criterion. For this study, 10,464 rows of labial teeth, as defined, were examined.

Any tadpole collection with less than 10 specimens was rejected as not being sufficiently

TABLE I  
NUMBER OF TADPOLES COLLECTED IN VARIOUS  
COUNTIES OF OKLAHOMA  
Counties arranged in east-west order

Species:	<i>Rana berlandieri</i>	<i>Bufo l. americanus</i>	<i>Pseudacris m. triseriata</i>	<i>Scaphiopus hurleri</i>	<i>Scaphiopus bombifrons</i>
Number: Collections: Years:	369 9 1938-49	303 10 1939-46	208 10 1947-49	300 8 1945-46	300 9 1940-49
Counties					
Delaware	15	..	..	..	..
Adair	..	47	..	..	..
Sequoyah	..	30	..	..	..
LeFlore	..	..	49	..	..
Cherokee	130	50	..	..	..
Craig	..	..	11	..	..
Haskell	..	..	25	..	..
Pushmataha	..	..	13	..	..
Nowata	153	..	..	..	..
Muskogee	..	36	39	..	..
Creek	..	..	..	..	104
Hughes	..	..	27	..	..
Payne	..	45	..	..	..
Cleveland	55	83	44	300	..
McClain	..	12	..	..	..
Major	..	..	..	..	46
Woodward	..	..	..	..	26
Dewey	..	..	..	..	34
Kiowa	16	..	..	..	..
Beckman	..	..	..	..	25
Greer	..	..	..	..	39
Jackson	..	..	..	..	26

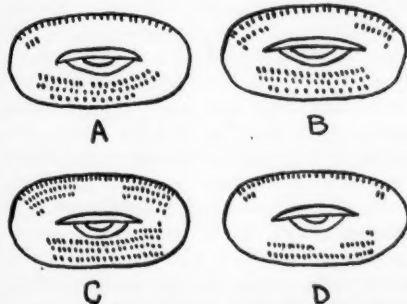


Fig. 1. Diagrammatic composites of tadpole mouthparts demonstrating various labial formulae. A, 2/3; B, 2/3; C, 3/4; D, 2/2.

TABLE II  
LABIAL FORMULA PERCENTAGES IN TADPOLES OF FIVE SPECIES

Species and number of specimens	Number of upper labial rows	Number of lower labial rows						
		1	2	3	4	5	6	7
<i>Rana berlandieri</i> (369)	1	..	..	0.3	..	..	..	..
	2	..	0.8	75.1	1.9	..	..	..
	3	..	..	21.4	0.5	..	..	..
<i>Bufo t. americanus</i> (303)	1	..	..	0.3	..	..	..	..
	2	..	0.3	99.0	..	..	..	..
	3	..	..	0.3	..	..	..	..
<i>Pseudacris nigrita triseriata</i> (208)	1	..	0.5	..	..	..	..	..
	2	0.5	4.8	93.3	..	..	..	..
	3	..	..	0.9	..	..	..	..
<i>Scaphiopus huerteri</i> (300)	4	..	..	..	1.7	9.7	..	..
	5	..	..	..	0.7	33.3	42.3	1.3
	6	..	..	..	..	..	8.3	2.3
	7	..	..	..	..	..	0.3	..
<i>Scaphiopus bombifrons</i> (300)	2	..	0.3	1.0	2.3	..	..	..
	3	..	..	5.3	18.7	0.3	0.7	..
	4	..	..	4.7	42.6	6.7	0.3	..
	5	..	0.3	0.3	9.0	3.0	0.3	..
	6	..	..	..	2.3	1.0	0.7	..

representative of a station. Admittedly, this may have resulted in the removal of some legitimate variations from consideration. Certain collections contained hundreds of specimens. From each of these collections approximately 50 specimens were taken at random for examination.

Approximately one percent of the tadpoles examined had very irregular rows of teeth which could not be judged accurately. These animals were eliminated from further study.

A tadpole acquires rows of teeth during its period of early development and loses them during the period of metamorphosis. In these two periods the labial formula changes rapidly and is of little use for purposes of classification. In order to be certain that tadpoles were being examined while they were in the mid-period of development, the best period in which labial teeth can be used to advantage for classification, another criterion was followed. It was found that tadpoles of a certain minimum length have a complement of teeth characteristic of the species involved. This relationship was established for the following forms: *Rana*

*berlandieri*, 20 mm.; *Scaphiopus huerteri* and *Scaphiopus bombifrons*, 17 mm.; *Pseudacris n. triseriata*, 15 mm.; *Bufo t. americanus* (the dwarf form), 12 mm. Any tadpole with a total length less than its specified minimum length was rejected.

Since there were insufficient collections available to determine whether or not any relationship existed between the labial formulae and the date of collection, all the animals for a particular species were grouped together (Table I).

Generally, the length of a vertebrate is related to its overall development. In *Scaphiopus huerteri* and *Scaphiopus bombifrons* a definite tendency for the rows of teeth to be more numerous in longer animals was noted. *Rana berlandieri*, in this study, showed a very slight increase in the number of labial rows with development of the tadpoles. *Bufo t. americanus* and *Pseudacris n. triseriata* showed no increase in the number of rows with development (or length). Therefore, there appears to be no generalization which can be made regarding the increase of tooth rows during the tadpole

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period. However, on the basis of the 1,480 specimens used in this study and other examinations (unpublished data), it appears that various members of a genus exhibit similar tendencies to increase or not to increase the number of rows with ontogeny.

This quantitative study generally substantiates the statements found in the literature concerning typical labial formulae and shows variations among species in the percentages of specimens in which these formulae occur (Table II).

The authors are indebted to the Museum of the University of Oklahoma and to the Okla-

homa Biological Survey for permission to examine many specimens. Gratitude is expressed to Dr. S. Charles Kendeigh, University of Illinois, for a critical reading of the manuscript and for helpful suggestions.

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## Observations on the Life History of the Salamander *Necturus louisianensis*

FRED R. CAGLE

**C**OLLECTING series of *Necturus* essential to the clarification of the status of the central Louisiana populations has resulted in the accumulation of some information on the life history of *N. louisianensis*.

Tulane field crews collected 72 adults and larvae during six trips to the type locality of *Necturus louisianensis* (Big Creek, east of Pollock, Louisiana); 41 of these were taken on a single trip. Although various collecting devices were used (baited nets, dip nets, seines, hand lines, set lines, trot lines), only set lines produced satisfactory catches of adults; larvae were obtained only by intensive work with dip nets and seines. Attempts to collect adults during June, July and August were unsuccessful, but adults were easily obtained during January and February. Larvae were taken during each of the six trips.

Big Creek varies much in width and depth. In some sections it is less than 15 feet in width and in others it may be as wide as 60 feet. At Fishville, where most of the specimens were taken, the creek at normal water levels may have a maximum depth of 3 feet. Deeper areas along the stream have a depth of 20 feet or more. One such area near Fishville has been converted into a local swimming pool which furnishes a most suitable habitat for *Necturus*.

The results of set-line operation suggested that there was a diel cycle of activity and a tendency for the animals to concentrate in the deeper holes near the roots of trees or at the mouths of inlets. Systematic operation of lines on January 23, 24 and 25, 1951 provided data useful in the determination of the diel cycle. Forty-five single-hook hand lines were operated, from 38 hours and 17 minutes to 38 hours and 52 minutes each, from the afternoon of February 23 to the afternoon of February 25. These lines were examined at approximately 30-minute intervals during the entire period. Each hook was baited at every examination and a notation made of the results (animals caught or bait removed). A record was thus available for the yield from each line. Hooks were not set in suspected ideal niches for *Necturus* but were distributed along the banks of the pool and the creek for a distance of approximately one-quarter mile.

On February 23, hooks were operated for 5 hours and 55 minutes to 8 hours, a mean of 7 hours. On February 24, each hook was operated for a 24-hour period. On February 25, each hook was operated for a period of from 8 hours and 17 minutes to 9 hours and 1 minute, a mean of 8 hours and 45 minutes. Twenty-one individuals were taken on February 23, 15 on



February 24, and 3 on February 25. Hooks were left in the same location each day. Of the 45 hooks, 16 caught only one animal each, 5 caught two each, 2 caught three each, but 1 caught eight; the other 17 captured none.

The fact that one set caught eight individuals suggests that this particular line was operating in an exceptionally favorable section. On the first day of operation this hook took its first animal, a female, at 3:16 in the afternoon. At 3:24 a male was captured. At 2:36 the next morning a female was taken, and a male at 6:46. Four additional specimens were taken on this same hook on February 24, but none was taken on February 25. The line was set with the hook on the bottom in about 3 feet of water. Possibly the explanation of the efficiency of this hook lies in the fact that the bait was immediately adjacent to an irregular pile of stones. There was, however, similar cover adjacent to other hooks that did not yield returns.

Only two other hooks caught more than one animal on the same day; hooks Nos. 11 and 42 each caught two. In contrast, 6 hooks caught more than one animal on successive days. Set No. 44 caught three animals, one on each day. No hook took a specimen on February 23, failed on the 24th, and functioned on the 25th. If it took a specimen on the 23rd, it took none thereafter, or captured one on the 24th and also functioned on the 25th.

The fact that no hook skipped a day capturing a specimen suggests that the hooks operated efficiently in removing any animals close enough to react to the bait, and that there was very little wandering of individuals up and down the banks. This absence of random movement or wandering is also suggested by the fact that so few hooks took specimens, and by earlier trot line sets in which only those hooks along the bank and those in apparently favorable niches produced results. Too, the failure of collectors to observe animals wandering about in the small tributary streams at night reinforces the view that these animals do not wander extensively in this locality.

During the period from 1 AM to 8 AM, nine animals (six males and three females) were taken; from 8 AM to 4 PM, only one male was taken; from 4 PM to midnight, 29 animals

(13 males and 16 females) were taken. If these records are separated in terms of periods of darkness and light, 12 animals were taken during daylight hours and 27 during hours of darkness. It could not be determined positively whether four of these were captured during hours of lightness or darkness. These data suggest that the greater part of the activity occurs during darkness.

Hand lines operated in other localities have produced best results during hours of darkness. The interpretation of this correlation is questionable, however, as many of the lines were set in muddied water where there was probably little change in light intensity between the hours of light and the hours of darkness.

During the period of hook operation, workers seined and dip netted intensively in attempts to collect larvae. The most productive dip netting was done in shallow holes on the bottom where leaves and twigs, accumulated to a depth of several inches, provided shelter for the young larvae. Another technique was also successful. While two workers held a seine across the current, others stirred through the upstream bottom debris trying to dislocate animals so that they might be carried downstream into the seine. This method yielded two larvae during several hours of operation. Although no adults were taken from bottom material, one was taken from well consolidated debris forming a bank along one edge of the stream. This animal had apparently burrowed far up into the bank and was captured when the loosened debris was carried into the seine.

Local residents who were acquainted with these animals insisted that they occurred only in deep water, were rarely caught during the daytime, and that hooks placed out over night during January, February and March usually caught either eels or "waterdevils."

The results of trot-line operation on January 14 and 15, 1950 provided supplementary information on habitat preference. Big Creek was near flood stage, the water being within 4 feet of the bank top. The water was muddy except in the small tributary streams.

On the first night attempts were made to set lines in a variety of situations. Fifty hooks baited with liver were set 20 inches below the surface in water 6 feet deep near the bank but

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not in the direct current. No animals were taken and all the bait was intact the next morning. A line of 100 hooks was stretched along the bank with 10 of the hooks on the bottom in static, shallow water and the remainder in current. One individual was caught by a hook on the bottom, and all bottom hooks lost their bait. All hooks set over current had the bait intact the next morning.

Fifty hooks were set in a swirling current in water estimated to be more than 8 feet in depth. The center section of this line was weighted to the bottom in anticipation that animals wandering about on the bottom of the pool would be attracted to this bait. All of the hooks of the center section were cleared of bait when examined the next morning but no animals were taken. The hooks not on the bottom had the bait intact. Hooks set along the bank on hand lines with the bait not on the bottom also yielded no results.

All of the hooks were moved on the night of January 15 to other sites. One set of 50 hooks baited with crawfish and liver was placed in clear water 1 to 3 feet in depth near the mouth of a tributary. Two large adults were removed from liver-baited hooks the next morning. The water here was almost static.

Twenty-eight hand lines with two hooks each were set in selected areas the same night around edges of pools, bases of trees, and at the mouths of rivulets flowing into the main creek. In early evening, before 8 o'clock, one animal was caught at the base of a tree near the entrance of a small inlet. Early in the morning two additional ones were taken within 6 feet of this site.

The results of set- and trot-line operation indicate that these animals inhabit shallow or deep standing waters where they may find some measure of cover (roots of trees, piles of rocks, submerged logs, cavities within the bank), and that such shelters may harbor a number of individuals. It is also suggested that these animals do not ordinarily wander far from points of shelter, and that most of their activity is during the hours of darkness. Although these data indicate that the animals feed consistently on the bottom, hook-and-line fishermen report that some were caught on shallow-set hooks.

Of 76 individuals deposited in the Tulane Collections, 29 are juveniles, 23 are females, and 24 are males. The term "juvenile" is used here tentatively to indicate the animals still retaining attributes of young larvae and not having attained the size of sexual maturity. The 29 larvae ranged in size from 3.43 cm. to 6.15 cm. (snout-vent length). The males ranged from 11.5 cm. to 18.0 cm. and only one of them (the smallest individual) was not sexually active. The females ranged from 11.8 cm. (smallest individual taken on a hook) to 16.4 cm. Four of these (13.3–15.2 cm.) were either sexually immature or were not reproductively active, as they had no ova larger than 1 mm. Other individuals had ova 4 mm. to 5 mm. in diameter—ova that were apparently ready for ovulation.

Attempts made to obtain individuals in the size range of 7 cm. to 11 cm. were unsuccessful, as they could not be obtained by trot lining, seining or dip netting. The absence of this size group may be a reflection of the time of collecting (June, January and February by the Tulane crews). A collection made July 20, 1937, included larvae ranging in size from 3.70 cm. to 4.25 cm. Another made June 14, 1950, contained larvae ranging from 3.76 cm. to 5.0 cm. Six larvae collected by Mr. Percy Viosca, September 6 to 8, 1938, from Big Creek ranged from 1.93 cm. to 4.33 cm. The smallest individual was apparently just hatched. Of the females with large ova (4–5 mm. in diameter), collected in January and February, none had ovulated. Oviposition may occur in May or June, and the small larvae may appear during July and August.

The sexually mature males collected during January and February had the cloacal glands much enlarged. This condition suggests that courtship may have been occurring. Courtship in *Necturus maculosus* occurs some months prior to egg deposition. It has been pointed out by Bishop (1941) that the swollen and inflamed condition in males is maintained for several months. It is thus not possible to determine the time of egg laying by the condition of the males. None of the females had spermatophores in the cloaca.

Most of the stomachs of the adults contained only fragments of bait. The habit of the animal

of striking and engulfing its food rapidly was clearly indicated by the presence of hooks embedded in the stomach walls. The five animals containing food other than bait had fragments of crawfish, dragonfly larvae, and one fish (*Notropis* sp.).

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## Variation and Predator Pressure in an Island and a Mainland Population of Lizards

A. STANLEY RAND

IN the course of routine work on the Honduras reptile collections in the Chicago Natural History Museum, certain differences between the specimens of *Cnemidophorus lemniscatus* from Ruatan, Bay Islands and those from the mainland became apparent.

Barbour (1928) described *Cnemidophorus lemniscatus ruatanus* on the basis of a single specimen from Ruatan. He distinguished it from *C. l. lemniscatus* of the mainland of Central America because it had a single scale between the outer parietal and the enlarged postorbital instead of two or more. Charles Burt in his revision of the genus (1931) synonymized *ruatanus* with *C. l. lemniscatus* because this character could be duplicated in specimens from the mainland.

A series of 47 *Cnemidophorus lemniscatus* collected on Ruatan by D. D. Davis and 13 specimens from the mainland of Honduras have made it possible to evaluate the taxonomic status of *C. l. ruatanus*. In addition the greater variability of the island form was found to be correlated with natural selection.

In studying these lizards use was made of seven head scale characters (Table I), femoral pores, head-body and total length, ventral coloration, and dorsal pattern. The head-body length was measured from the tip of the snout to the anterior margin of the vent; the total length from the tip of the snout to the tip of the complete tail. The pattern was recorded as the number of stripes at midbody.

The number of femoral pores in the Ruatan lizards may be a little greater than in the mainland ones. The Ruatan males have 18-24 (21.4) and the females 19-22 (20.7); the main-

land males have 19-23 (21.2) the females 20-22 (20.4).

The head-body length of the two populations is similar. The maximum size in the mainland males is 81 mm., females 71 mm.; in the island series males 83 mm., females 64 mm. There is also little difference in the ratio of head-body length to tail length.

The basic dorsal pattern in these lizards is a mid-dorsal light stripe of varying width and four narrow light lines on each side between it and the venter. As the animals increase in size this pattern changes. In the males spots replace the lateral lines and also appear in the spaces between them. In the females the lines become obscure and disappear, but are not replaced by spots. There is a difference between the mainland and the Ruatan populations in that the basic pattern is retained to a larger size on the island (Table II).

Ventral coloration is slightly different in these two populations, the mainland series having a somewhat more blue venter than the island specimens.

These data show that the mainland and island populations are different. Though the differences in scutellation are slight and the differences in ventral coloration may be at least partly due to preservation, retention of the dorsal pattern to a larger size in the island lizards, in combination with the other characters, seems to be worth emphasizing by retaining the name *ruatanus*.

It is known that in certain snakes and one lizard that the range of variation in the juveniles is greater than that in the adults. Apparently natural selection eliminates the more

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TABLE I

VARIATION IN HEAD SCALES IN ISLAND AND MAINLAND LIZARDS

Character and locality	Scale counts								
	1-1	1-2	2-2	2-3	3-3	3-4	4-4	4-5	
Chinshields									
Ruatan	..	..	..	..	0	0	45	2	
Mainland	..	..	..	..	1	3	9	0	
Loreals									
Ruatan	40	6	1	..	..	..	..	..	
Mainland	13	0	0	..	..	..	..	..	
Supraocular granules									
Ruatan	..	..	20	9	14	2	0	0	
Mainland	..	..	0	1	5	3	1	2	
Anterior suboculars									
Ruatan	23	14	8	0	1	..	..	..	
Mainland	12	1	0	0	0	..	..	..	
Anterior supraoculars									
Ruatan	7	14	25	0	0	..	..	..	
Mainland	0	0	11	1	1	..	..	..	
Character and locality	Scale counts								
	5-7	6-6	6-7	7-7	7-8	8-8			
Sublabials									
Ruatan	2	2	5	36	1	..			
Mainland	0	0	0	9	0	..			
Supralabials									
Ruatan	..	..	..	47	0	0			
Mainland	..	..	..	11	1	1			

aberrant young (Dunn 1915, 1942; Inger, 1943; Mertens, 1947; and Hecht, 1952). In both the work of Inger and of Hecht an adaptive structure, the number of ventrals in a snake and of toe laminae in a gecko, were involved. In Dunn's work on head scales in snakes no evident adaptive factors were involved.

In the present material there is much variability in the head scales. Modes for the various characters were determined and each individual was examined to ascertain the number of characters in which it differed from these modes. As the numbers of scales on both sides

TABLE II

BASIC PATTERN RETENTION IN MAINLAND AND ISLAND LIZARDS

Sex and locality	Size (mm.)	Lines at midbody				
		0	2	4	6	8
Males						
Ruatan	61-83	0	1	13	2	0
Mainland	61-81	2	3	1	0	0
Females						
Ruatan	60-71	0	0	2	1	15
Mainland	60-64	0	2	1	1	0

TABLE III

VARIABILITY IN HEAD SCALES AMONG 47 ISLAND AND 13 MAINLAND LIZARDS

Locality	Number of characters varying from mode						
	0	1	2	3	4	5	6
Ruatan	3	11	10	9	8	4	2
Mainland	4	4	2	3	..	..	..

of the head were not always the same, the seven characters were counted on each side, giving a possible variation of 14. Thus an animal all of whose characters were modal was tabulated as 0; one in which six characters differed from the modes was tabulated as 6, the highest degree of variability noted. The Ruatan lizards were found to be more variable than those from the mainland (Table III). That this phenomenon is not due to a greatly disproportionate number of juveniles is indicated by the fact that five of 47 from Ruatan and one of 13 from the mainland were less than 50 mm. in head-body length.

No adaptive factors are evident in this variation in head scales. However the specimens examined yield one further set of data: an indication of predator pressure in the frequency with which regenerated tails are present.

These lizards lose their tails easily when seized. The residual stump then begins to regenerate a new tail, but one less perfect in scutellation and easily recognized. If the ratio between the lizards escaping capture and those being killed is roughly constant, populations subjected to differential predation pressures would be expected to contain different propor-

tions of animals with damaged tails. Since the ratio of regenerated tails in the island specimens as compared to those from the mainland is 1:8, it appears that predation on the mainland is about eight times as great as on the island. Presumably on the mainland where the pressure is high the aberrant individuals are weeded out and the population is relatively uniform. But on the island where predation pressure is lower the population as a whole is more variable.

It is improbable that these apparently insignificant variations in head scales should affect the lizards' ability to escape capture. Dunn has suggested that varietal characters of this type must be correlated with others that are directly concerned with survival.

That the absence of predators on islands allows forms to develop and survive that would not do so on the mainland has been postulated as an island effect. This is one of the few cases

in which evidence of predator pressure and variability can be so well correlated.

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CHESTERTON, INDIANA.

## A Horned Toad, *Phrynosoma cornutum*, from the Upper Pliocene of Kansas

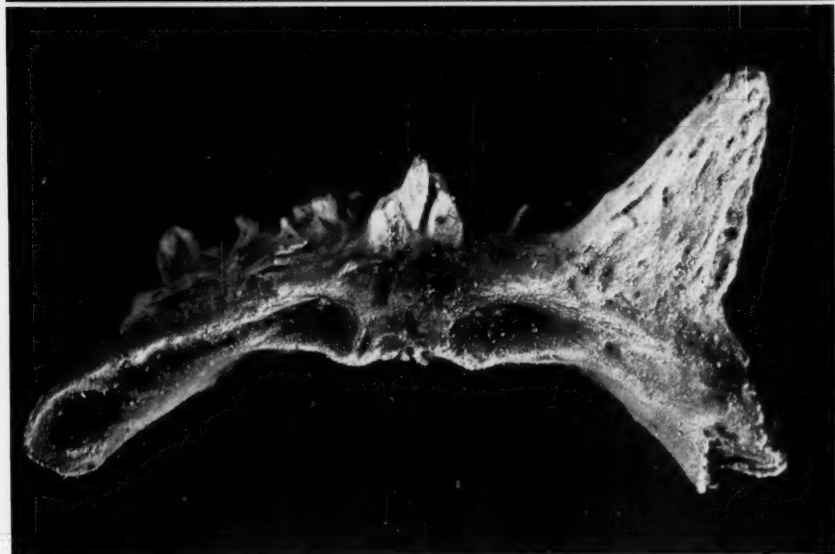
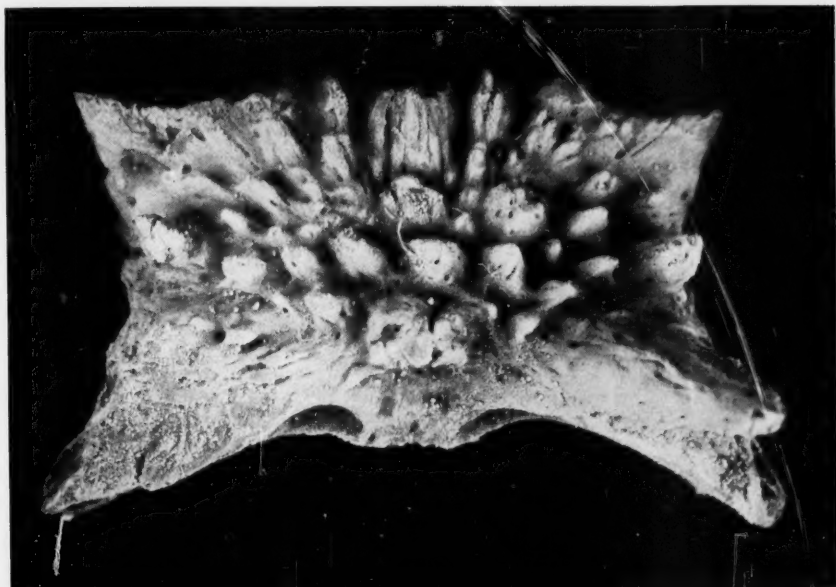
THOMAS M. OELRICH

ALTHOUGH the Rexroad fauna (Hibbard, 1950) is the best known vertebrate fauna of Pliocene age in North America, the reptiles are extremely scarce. Two species of turtles represented by *Gopherus riggsi* (Hibbard) 1944, and *Testudo rexroadensis* Oelrich (1952), one species of snake *Heterodon plionasicus* Peters (1953), and five species of lizards, *Cnemidophorus bilobatus*, *Eumeces striatulus*, *Eumecoides hibbardi* and *Eumecoides mylecoelus* all described by Taylor (1941) and *Sceloporus robustus* Twente (1953), complete the list. The occurrence of *Phrynosoma* has long been expected. Due to the disarticulated condition of the material, species identification is limited to maxillae and dentaries with the notable exception of the parietal of a horned toad.

I would like to express appreciation to Dr. Claude W. Hibbard, Museum of Paleontology, University of Michigan, for making this specimen available to me, and to Dr. E. H. Taylor, University of Kansas Museum of Natural History, for the loan of recent skeletal material.

In the summer of 1952 the field party of the University of Michigan Museum of Paleontology under the direction of Claude W. Hibbard recovered from the type locality of the Rexroad formation, and Rexroad fauna, Locality No. 3, W $\frac{1}{2}$  SW $\frac{1}{4}$  Sec. 22, T/33S, R/29W, Meade County, Kansas, a single parietal, Museum of Paleontology, University of Michigan No. 30191, of a horned toad. The specimen is very well preserved; however, it possesses only a single horn. The loss of the horn does not appear to be due to erosion or breakage. Comparison of this specimen with Recent species of North America indicates that it belongs to the *Phrynosoma cornutum* group (Plate I).

The parietal is 10 mm. wide and 5 mm. long (greatest length). Comparison with parietals of medium sized *P. cornutum* shows only one distinguishing character: along the posterior border of the parietal are two well developed recesses which receive the insertion of the spinalis dorsi muscle. In Recent forms of



Dorsal and posterior views of parietal bone of *Phrynosoma cornutum* from the Rexroad Formation of Kansas

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*P. cornutum* excavation of this extent was not seen; however, in *Phrynosoma modestum* a similar excavation is present. This is probably an individual character.

Only one other fossil record of *Phrynosoma* is known. This is from Conard fissure, Arkansas, and is of late Pleistocene age (Gilmore, 1928). The Conard fissure specimens are maxilla and dentaries which are referred to *Phrynosoma* sp. The middle Oligocene lizard *Exostinus serratus* (Cope) has been suggested as a possible ancestral *Phrynosoma* (Gilmore, 1941; Reeve, 1952).

The present distribution of *P. cornutum* (Smith, 1946, Map 20) is distinctly southwestern. If the Pliocene forms had similar climatic demands as do the Recent related ones, then the presence of *P. cornutum* along with the other reptiles in this fauna indicates a warm temperate climate. The extremely large mammalian, avian, amphibian and invertebrate fauna indicates a mild temperate climate with demands for numerous aquatic habitats (Hibbard, 1950). The assignment of the Rexroad deposits containing the Rexroad fauna and the older Saw Rock Canyon fauna (Hibbard, 1953) to post-Nebraskan till, Pleistocene age, by Frye and Leonard (1952), would therefore seem untenable according to the vertebrate faunas.

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## Crocodilian Remains from the Pleistocene of Celebes

D. A. HOOIJER

THE two fragments of crocodilian dentaries described below form part of a collection of fossils made at Sompoh, near Tjabengé (Sopeng district), about 100 km. NE of Macassar in southwestern Celebes. Earlier finds have been mentioned elsewhere (Hooijer, 1948 a-c, 1949, 1950). No specific determination is here attempted, yet it seems worth while to draw attention to these remains because they are the first evidence ever obtained of crocodiles occurring in the Pleistocene of Celebes. It is a great pleasure to acknowledge my indebted-

ness to the Head of the Dinas Purbakala R. I. at Jakarta, Java, Indonesia, who entrusted these fossils to me for study, and to Mr. H. R. van Heekeren who was responsible for collecting. The figures illustrating this paper are by Mr. H. Heyn of the Museum of Natural History at Leiden.

Recent material used for comparison consists of a good series of *Crocodylus porosus* as well as a few skulls of *C. palustris* and *C. siamensis*, all in the Leiden Museum of Natural History. The literature was consulted for the

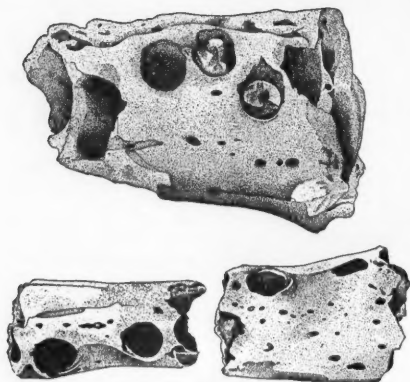


Fig. 1. Upper: Larger fragment of left dentary of *Crocodylus* sp., with alveoli (from right to left) of fourth to ninth tooth, inclusive. Part of sixth and seventh teeth are present in their respective alveoli. Lower: Smaller fragment of left dentary of *Crocodylus* sp., with alveoli (left to right) of eighth and ninth teeth. Left, upper view; right, outer view.

specific characters of *C. novaeguineae* and *C. mindorensis*, but these accounts have not been found relevant to the portion of the dentary here represented.

The most complete specimen is a heavily fossilized fragment of the left dentary (Fig. 1, upper). Its inner border (below in the figure) is curved inward anteriorly (right side of the figure), a clear sign that the dentary is broken off at the posterior edge of the symphysis. No splenial is preserved, but the rough concavity of the inner surface which lodged it shows that it extended forward to about 3 cm. from the posterior edge of the symphysis. Hence the splenial does not form part of the symphysis; this is a characteristic of *Crocodylus*.

In the broken anterior surface of the fragment the basal portion of the alveolus for the enlarged fourth mandibular tooth, about 22 mm. in diameter, is inclined forward. The fractural plane slopes backward toward the upper surface, and intersects the alveolus of the fifth tooth just in its center at the upper surface of the dentary. The anterior projection of the inner border of the dentary, that marks the posterior edge of the symphysis, shows that the symphysis extends backward to the front of the fifth tooth. The large fourth tooth must have been entirely in front of the posterior edge of the symphysis at the upper surface of the dentary.

Fortunately, the position of the enlarged fourth mandibular tooth relative to the posterior border of the symphysis is of some systematic significance (Boulenger, 1889; Mook, 1921; Kälin, 1933). In the common estuarine crocodile of the Indo-Australian Archipelago, *Crocodylus porosus*, the symphysis extends backward at least as far as the fifth mandibular tooth; in *C. palustris* to the level of the fourth or fifth tooth; in *C. siamensis* only to the fourth tooth. A certain amount of variation in these characters can be observed. Thus, in a series of seven skulls of *C. porosus* the position of the posterior edge of the symphysis ranges from the front of the fifth tooth to the middle of the sixth tooth. In *C. siamensis*, however, the symphysis is always shorter, extending only to the fourth mandibular tooth. Consequently, the fossil dentary, in the above discussed character, agrees with both *C. porosus* and *C. palustris*, but not with *C. siamensis*.

In the fossil specimen the alveoli of the fifth to, and including, the eighth mandibular tooth are small, 12 to 13 mm. in diameter only, and rather close together. Behind the alveolus of the eighth tooth there is a diastema of 10 mm., and at this level the heavily pitted outer surface of the dentary is curved inward. The dentary is broken off obliquely through the alveolus of the ninth tooth, which is likewise small but placed on a higher level than the alveoli in front of it.

The difference between the fossil fragment and recent dentaries is in the crowding of the teeth in the former, suggesting a relatively short dentary. In recent specimens the mandibular teeth are rather widely spaced and set approximately in a straight line. In the fossil dentary, if a straight line is drawn from the center of the fifth to that of the ninth tooth, the sixth tooth is internal, and the seventh and eighth are external to this line (Fig. 1). There is hardly any space between the teeth of the fossil dentary except between the eighth and the ninth tooth. In dentaries of Recent species the greatest diastema is also between the eighth and the ninth tooth, and there is also a depression of the outer surface, which serves for the reception of the large fifth maxillary tooth. Furthermore, in Recent crocodilian skulls the dentary is somewhat higher at the ninth tooth. In all of these characters there is a close re-

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TABLE I  
MEASUREMENTS (IN MM.) OF TWO FOSSIL DENTARIES COMPARED WITH THOSE OF SEVEN SPECIMENS  
(identified by letter) of *Crocodylus porosus* IN THE LEIDEN MUSEUM

Characteristics	Fossils		<i>Crocodylus porosus</i>						
	No. 1	No. 2	h	p	o	e	f	a	n
Skull length (premaxillae-condyle)	..	..	442	463	509	518	603	607	662
Width of dentary between 6th and 7th tooth	59	..	31	34	44	35	38	40	57
Height, same level	53	..	32	29	36	36	38	41	58
Height between 8th and 9th tooth	56	35	35	34	41	37	42	45	61
Length from posterior border of 5th to anterior border of 9th tooth	50	..	64	69	72	79	99	94	85
Distance from symphysis to middle of diastema between 8th and 9th tooth	97	..	88	95	97	106	133	120	120
Length from posterior border of 7th to anterior border of 10th tooth	..	45	54	55	60	65	79	79	72
Longer diameter of alveolus									
8th tooth	13	10	11	11	13	13	15	16	15
9th tooth	..	10	11	11	13	13	15	16	15
Diastemata width									
7th to 8th tooth	3	4	7	9	11	11	14	12	12
8th to 9th tooth	10	14	14	17	17	20	24	23	22
9th to 10th tooth	..	4	6	6	7	8	12	13	7

semblance of the fossil to the Recent specimens; only the shortness of the dentary, and the crowding of its teeth, which do not stand in line, require further attention.

As noted above, the irregular arrangement of the alveoli in the fossil is mainly the result of an inward displacement of the sixth tooth. This may be an anomaly or a specific character. Anomalies in the crocodile skull, such as those described by De Jong (1928) and Kälin (1937), may involve the number as well as the alignment of the teeth. In the present specimen there are no indications that the condition is abnormal; on the contrary, the crowding of the teeth seems to be a function of the general shortness of the dentary as a whole. It appears that both of these characters are proportional or harmonic. Measurements show that, while

in width and height the fossil dentary agrees best with the largest Recent specimen of *Crocodylus porosus*, the length from the posterior border of the alveolus of the fifth tooth to the anterior border of the alveolus of the ninth tooth is even less than that in the smallest of the series of Recent skulls. The measurement from the posterior lower edge of the symphysis to the middle of the diastema between the eighth and ninth tooth (one of the few length measurements that can be taken from the fossil fragment) also shows that the Celebean dentary is decidedly shorter than that of *Crocodylus porosus* of the same bulk. (Table I, specimen No. 1).

Fortunately, there is a fragment of another dentary (Fig. 1, lower left and right) in the

collection that Mr. Van Heekeren brought together at Sompoh, and this helps somewhat toward a solution of the problem as to whether the differences between the fossil and the Recent dentaries are constant.

This smaller fragment contains two alveoli, and is broken off in front as well as behind through an alveolus. The alveoli that are completely preserved are slightly longer anteroposteriorly than wide in cross section, and the pitting on the outer surface is not heavy. The splenial is gone, but its imprint on the dentary remains. The diastema between the two complete alveoli is much longer than the one in front and the one behind it; the outer surface of the dentary between the two complete alveoli is depressed, and the dentary is higher at one of these alveoli than it is at the other. These characters in combination show that the preserved portion is that part of the left dentary containing the eighth and the ninth teeth. Comparison with Recent dentaries again shows that the teeth are closer together in the fossils (Table I, specimen No. 2). In height, moreover, the fossil dentary agrees with the smallest of the Recent series, but the length from the posterior border of the alveolus of the 7th tooth to the anterior border of that of the 10th is decidedly less.

Both the large and the small fossil dentary fragments from Sompoh agree in that their teeth are somewhat more closely approximated than are those in *Crocodylus porosus*.

The presence in the Pleistocene of Celebes of a kind of crocodile seemingly different from all the other known species of its genus seems remarkable in view of the fact that Müller (1923) has shown that *Crocodylus ossifragus* Dubois, from the Pleistocene of Java, is identical with the living *Crocodylus siamensis*. But this discovery should be seen in the light of a remark by Schmidt (1935) who observed that "... it is reasonable to suspect another undescribed species in the ancient lakes of Celebes."

# SUMMARY

A description is given of two fossil fragments of dentaries of a species of *Crocodylus* originating from probably Pleistocene deposits in southwestern Celebes. These fossils are the first crocodilian remains to be made known from the island of Celebes. The larger fragment, a left dentary showing the alveoli for the fourth to (and including) the ninth tooth, is remarkable because of the irregular arrangement of the teeth. The smaller dentary fragment, a portion that contains the alveoli of the eighth and ninth tooth, is also suggestive of a general shortness of the dentary. Comparisons made with a series of recent Indo-Australian crocodiles suggest specific difference rather than anomaly.

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# Differential Vertical Distribution of the Sexes in *Gibbonsia elegans* with Remarks on Two Nominal Subspecies of this Fish

GEORGE C. WILLIAMS

THE blennioid fish, *Gibbonsia elegans* (Cooper), is a brightly colored, slender bodied inhabitant of dense seaweed beds on the California coast from the lower intertidal level to depths of about thirty meters. It occurs most abundantly in rocky areas of the open coast, but is also found in eel grass and other vegetation of calm bays. Maximum length is about 120 mm.

This paper presents evidence that the males and females of this species have different bathymetric distributions, and discusses the bearing of this evidence and other considerations on the validity of two recently proposed subspecies, *Gibbonsia elegans elegans* and *G. elegans velifera* Hubbs. I believe that the morphological differences between these two forms, although undoubtedly real, may be merely phenotypic, a reflection of direct environmental influences, not of phylogenetic divergence.

The observations reported in this paper were made possible by the friendly cooperation of many people. I am indebted to Dr. Carl L. Hubbs and Kenneth S. Norris of Scripps Institution of Oceanography (University of California), W. I. Follett of the California Academy of Sciences, and Miss Margaret Storey of Stanford University for the use of collections kept at their respective institutions. In my own collecting I have been ably assisted by Richard H. Rosenblatt, Jay C. Quast and other graduate students of the University of California at Los Angeles. Dr. Boyd W. Walker and Dr. Waldo H. Ferguson of this University and Dr. Carl L. Hubbs have aided immeasurably by their many valuable suggestions, both in the conduct of the investigations and the preparation of the manuscript. Responsibility for any forthcoming errors or misinterpretations is, however, entirely my own.

## MATERIALS AND METHODS

The data to be presented were derived from 51 collections totalling 777 specimens. Thirty-six collections (628 specimens) are included in the fish collection of the Zoology Department of the University of California at Los

Angeles, and are housed partly at the University and partly at the California Academy of Sciences in San Francisco. Other material, mostly from habitats poorly represented in the U. C. L. A. collection was borrowed from other institutions. This includes ten collections (77 specimens) from Scripps Institution of Oceanography and five collections (72 specimens) from Stanford University. Other available collections were examined, but are not considered here, because they could not confidently be classified as to water depth by the available collection data. The collections were made between April, 1946 and August, 1953.

Sexes were determined by examination of the gonads. The sexes are easily distinguished in specimens over 40 mm. in standard length. Sexual maturity occurs at about 60 mm.

The vertical distribution of the sexes was determined by comparing the sex ratios of samples taken from four different ranges of depth. Collections from all but the deepest range were made wholly or partly with rotenone and dip nets. The shallowest range considered is the lower intertidal zone, approximately 0 to 1.2 meters below mean sea level, and is represented by specimens taken from stranded pools at low tide. Samples taken at low tide from water broadly confluent with the ocean, but shallow enough to be covered by wading, represent the next range of depth to be considered, approximately 1.2 to 2.4 meters below mean sea level. Depths from 2.4 to 13 meters are represented by four collections. Three of these were taken with rotenone in water of from six to ten meters maximum depth, with the aid of boats and diving apparatus (aqualungs). The other collection from this depth range was dredged from 10 to 13 meter depths as determined by an echo sounder. Samples from the deepest range, from about 16 to 30 meters were also taken by dredging, with depths measured by echo sounders.

## CHANGES OF SEX RATIO WITH SIZE AND SEASON

Before different collections can be compared to determine the relationship of habitat to sex ratio, it is necessary to ascertain the size range



TABLE I  
SEX RATIOS OF INTERTIDAL AND SHALLOW  
SUBTIDAL FISH BY SIZE

Fish taken from 0 to 2.4 meters below mean sea level  
between March, 1951 and August, 1953

Standard length	♀♀	♂♂	Percent female
40-45 mm.	10	7	59
45-50 mm.	17	11	61
50-55 mm.	13	5	72
55-60 mm.	10	3	77
60-65 mm.	15	3	83
65-70 mm.	11	4	73
Over 70 mm.	260	68	79

TABLE II  
SEX RATIOS OF INTERTIDAL AND SHALLOW  
SUBTIDAL FISH BY SEASON

Depths and years are the same as for Table I

Depth in meters	Cold Jan.-March		Warming Apr.-June		Warm July-Sept.		Cooling Oct.-Dec.	
	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂	♀♀	♂♂
0-1.2	53	6	20	2	14	3	63	2
1.2-2.4	31	15	80	24	2	0	23	22
Season totals	84	21	100	26	16	3	86	24
Total percent female	80		79		84		78	

in which the one-sided sex ratios occur, and whether there is any seasonal change in these ratios. Extreme sex ratios occur only in shallow water, the 0 to 2.4 meter depths, where the females form an overwhelming majority. It is here only that the sex ratios are extreme enough and the samples large enough to indicate the relationship of sex ratio to size and season with any precision (Tables I and II).

Note in Table I that the 40- to 50-mm. fish show only a slight majority of females, but that the 50- to 55-mm. fish and all larger sizes approximate the adult sex ratio of 79 percent females. If only specimens above 50 mm. standard length are considered, it should then be legitimate to compare the sex ratios of different collections without further regard to the sizes of the specimens.

Many of the cases of aberrant sex ratios that are known among fishes are associated with breeding activities and occur seasonally on the

spawning grounds but not otherwise. My observations indicate that *Gibbonsia elegans* spawns most heavily in the winter months at Los Angeles. The spawning season may properly be said to include the whole year, however, since a few ripe adults and very small juveniles can be found at any season.

Seasonal differences in sex ratios of specimens longer than 50 mm. are considered in Table II, in which sex ratios are tabulated for four seasons that are based on my records of surf temperatures at Palos Verdes, near Los Angeles. Winter temperatures are generally 13° to 14°C., summer temperatures 18° to 19°C. In the Channel Islands area and parts of northern Lower California, temperatures are, by virtue of the California current and summer upwelling conditions, generally lower, less variable and less strictly seasonal; but the temperatures roughly parallel those found at Los Angeles. The table clearly indicates that the numerical superiority of the females in shallow water continues throughout the year. The most significant difference is between the warming and cooling seasons in the subtidal ratios. The difference is reversed in the intertidal material, however, the season totals showing approximately similar sex ratios. This lack of correlation between intertidal and shallow subtidal ratios is perhaps a reflection of variation among habitats within each range of depth. Clear indications of seasonal influences on sex ratio are lacking, so I assume that season has no gross influence on sex ratio, and that for fish longer than 50 mm., different samples may be compared without regard to the season at which they were collected.

#### VARIATION OF SEX RATIO WITH DEPTH

The sex ratios of *Gibbonsia elegans* from four different ranges of depth on open rocky coasts are compared in Table III. The two subspecies are considered together in this table. The difference in sex ratio between these two forms is considered later. The p-values opposite the brackets indicate the probability that the two ratios connected by each bracket were taken from one homogeneous population, and so constitute a measure of the significance of the difference between the two ratios. All probabilities were calculated by a normal curve test described by Rider (1939: 81-3). This table



TABLE III  
TOTAL SEX RATIOS OF FISH FROM  
DIFFERENT DEPTHS

Depth in meters	Number of samples	♀♀	♂♂	Percent female	Statistical evaluation
0 - 1.2	20	150	13	92	p = .000
1.2 - 2.4	10	136	62	69	
2.4 - 13	4	80	72	53	p = .001
16 - 30	17	82	86	49	p = .249

demonstrates that there is a great preponderance of females in the shallowest part of the habitat, with progressively increasing proportions of males with increasing depth, the males being in a slight majority in the deepest range considered. All differences except that between the two deepest ranges are highly significant. Thus there would appear to be a habitat difference between the sexes, with females ranging more abundantly into shallow water than the males. The rate of change of sex ratio with depth is apparently greatest in shallow water. Since the difference between the two deepest ranges is not significant, it is impossible to say how far the trend continues. It is apparent, however, that any further increase in the proportion of males beyond the thirteen-meter contour must be slight, and to be conclusively demonstrated, will require many more specimens than have yet been collected.

Unfortunately it has been necessary in Table III to compare shallow-water collections from Palos Verdes (near Los Angeles) with deep-water collections from the Channel Islands and other areas, and also to compare intertidal and shallow subtidal collections from

different localities in the Palos Verdes area. Although the large number of the collections and the high degrees of significance attained may justify this procedure to a certain extent, it is nevertheless desirable to consider the few collections that have been made at different depths at the same locality. Four such pairs of collections have been made (Table IV). On three occasions one series was taken from tide pools and the other from shallow subtidal water below the pools. In two of the three pairs of samples, higher proportions of females were taken intertidally than subtidally, with an approach to statistical significance in each case. The one collection that showed a higher proportion of females subtidally is the least significant. Also shown in this table is the higher proportion of females in a shallower dredge collection as opposed to a deeper one in the same area. While the differences presented are in no case highly significant, they provide, in the aggregate, some further justification for using material from diverse localities, as was done in Table III.

*Gibbonsia elegans* is found in weedy areas of bays as well as on the open coast. The bay collections that I have examined were made with beach seines, which take fish from shallow water near shore. If the sexes are distributed in bays as they are on the coast, we would expect the bay samples to show a female majority. I have examined three collections, each from a different bay, and found a preponderance of females in each case. The total is 34 females to 16 males. Ninety-five percent confidence limits for this ratio are 81 and 53 percent females (Wilks, 1949: 201), so appar-

TABLE IV  
SEX RATIOS OF BATHYMETRICALLY SEPARATED SERIES FROM SINGLE LOCALITIES  
All fish were taken in 1953

Time and place	Depth in meters	♀♀	♂♂	Percent female	Statistical evaluation
II: 11-12, Palos Verdes	0 - 1.2	18	2	90	p = .115
	1.2 - 2.4	5	2	71	
III: 11-13, Palos Verdes	0 - 1.2	35	4	90	p = .027
	1.2 - 2.4	20	8	71	
	0 - 1.2	7	1	88	
IV: 11, Palos Verdes	1.2 - 2.4	27	3	90	p = .581
	10 - 13	48	37	56	
VIII: 4-5, Coronados I.	18 - 30	50	44	53	p = .330

ently the females are in the majority in shallow water in bays as well as on the open coast. Unfortunately the abundant "snags," the prevalent currents and turbidity, and other difficulties have so far discouraged the collection of deep-water samples from bays, either by rotenone or drag-nets.

The observation of differences in the ecological distribution of the sexes in a species of supposedly sedentary marine fish is unexpected, and raises certain questions, the most conspicuous having to do with the behavior of the animal. We would not expect a species to evolve behavior patterns which would severely limit contact between the sexes at spawning time, so perhaps there are temporary vertical migrations in one or both sexes, at least in the shallower parts of the habitat. Since there is no sharply defined breeding season, individual migrations of this sort might have little influence on observed sex ratios, but might be detected in ways other than comparing ratios. If we had large series, collected simultaneously from different depths at the same locality, we might find a higher incidence of ripeness among females from deep water than shallow water; or perhaps that a considerable proportion of the deep-water females had the coloration and proportions more commonly seen in shallow water. Such observations would suggest that the females seek deeper water at spawning time. Future investigation of these possibilities is contemplated.

Other problems concern the functional basis for the observed sex ratios. Why should the females be found so much more abundantly in shallow water than the males? In some fishes the males remain on the spawning grounds for a longer time than the females. Perhaps suitable spawning conditions are not found in shallow water, and the males maintain more or less permanent territories in deep water spawning areas. We know almost nothing of the breeding habits of this fish, however, so we can only speculate about such matters.

We may also wonder if *Gibbonsia elegans* is unique, or if other species show differences in the vertical distribution of the sexes. Except for the soupfin shark (Ripley, 1946), no such phenomenon has hitherto been described in the literature. Investigation of other rocky-shore fishes of southern California is now in progress, and I hope that this paper will

stimulate workers in other areas to hunt for similar cases.

#### SEX RATIOS OF THE TWO SUBSPECIES

As was noted above, two subspecies of *Gibbonsia elegans* have been recognized in California waters (Hubbs, 1952). *G. e. elegans* (Cooper) is restricted to shallow water on rocky coasts of certain outlying islands and the mainland south of Point Conception. *G. elegans velifera* Hubbs occurs in shallow water on rocky coasts from Point Conception northward, and in calm bays and sloughs to the south. It is also found in deep water, below about the ten-meter contour, on the southern California coast, where it intergrades with the typical subspecies at intermediate depths. Except where otherwise specified, these and other observations on the morphology and distribution of these subspecies are those of Hubbs (1952).

It is apparent that the two shallowest ranges of depth considered (Tables III and IV) should provide examples of *elegans* only, and the deepest range should provide only *velifera*. Collections from the 2.4- to 13-meter depths may, however, approach or include the zone of contact and so provide examples of both forms and their presumed intergrades.

Morphological analysis of these possibly intermediate samples is illustrated in Figure 1, in which they are compared with a large series of *Gibbonsia elegans velifera* from the type locality and habitat of this subspecies, and with a representative sample of *G. e. elegans* from the intertidal zone at Palos Verdes. The parameter of morphology is a "character index," a tool first described by Hubbs and Whitlock (1929). It consists of a quantitative combination of the best characters used to distinguish the two forms of *Gibbonsia elegans* appear to be the relative elongation of the caudal region, the length of the first dorsal spine, and the length of the second dorsal soft-ray, all of which are long in *velifera* and short in *elegans*, and the head length, which is shorter in *velifera*. When the head length is divided by the sum of the first three characters listed, the resulting index should average much higher in *elegans*, and the graphs show that this is the case, the means of *elegans* and *velifera* lying about 2.4 standard deviations apart. Sex dimorphism,

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San Martin
Smugglers
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Fig. 1. Grades. morpho. *elegans* four sam. depth m. The graph (1953). T. tion. The tervals of blackness of the m. small P. are on S. nados Isl.

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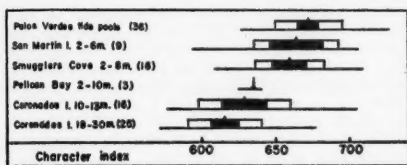


Fig. 1. Morphological status of possible intergrades. The graphs summarize the distributions of morphological character indices for *Gibbonsia elegans elegans* (top bar), *G. elegans velifera* (bottom), and four samples collected in the two-to-thirteen meter depth ranges (four middle figures).

The graphic form follows that proposed by Hubbs and Hubbs (1953). The heavy horizontal lines represent ranges of variation. The open rectangles describe one standard deviation intervals on either side of the mean (small central peak), and the blackened areas represent two standard errors on either side of the mean. Only the mean and range are shown in the very small Pelican Bay sample. Pelican Bay and Smugglers Cove are on Santa Cruz Island, California. San Martin and Coronados Islands are off the coast of Lower California.

TABLE V  
SEX RATIOS OF TWO SUBSPECIES AND  
THEIR INTERGRADES

Taxa	♀♀	♂♂	Percent female	Statistical evaluation
<i>Gibbonsia e. elegans</i>	303	93	77	} $p = .000$
Intergrades	63	54	54	
<i>Gibbonsia e. velifera</i>	82	86	49	} $p = .205$

incidentally, does not appear to contribute to this difference to any important extent. Instead of the usual measurement of caudal peduncle length, I have used another, perhaps more precise measurement of caudal elongation, namely, the distance from the hypural base in the midline to the base of the last dorsal spine. Since the proportions change with growth, a correction factor is needed to make large and small fish comparable. Adding a thousandth of the standard length (in millimeters) to the raw index described above approximately compensates for relative growth changes. It is this amended index that is used in Figure 1.

The means of all of the possibly intermediate collections investigated lie between the means of the two standards used. The difference between the San Martin Island and Palos Verdes collections, however, is small and readily attributed to sampling error. Indications of intermediacy are stronger for the other collections, as is indicated by the lack or paucity of overlap of the two standard error intervals. We might, then, regard the San Martin Island

collection as representative of *Gibbonsia elegans elegans* and regard the remaining three samples as intergrades. According to this classification, I have compared the sex ratios of the two subspecies and their intergrades in Table V. *Gibbonsia elegans velifera* is represented in the open coast collections that I have examined by a slight majority of males, *G. e. elegans* by a great majority of females, and the intergrades by an intermediate sex ratio. The differences between the two forms in nature may not be so great as the table would indicate, because the shallow-water collections are biased in favor of the shallowest part of the habitat. Statistical weighting of the deeper collections of the shallow-water form and various reinterpretations of the intergrades of Figure 1 do not, however, greatly modify the picture. For example, if we were to call all of the intergrades *Gibbonsia elegans elegans* and weight them equally with the shallow-water material, we are still left with a highly significant ( $p = .000$ ) difference of 17 per cent between the sex ratios of the two subspecies. Also it should be noted that really typical representatives of the shallow-water form may be confined to the shallowest part of the habitat, where the most extreme sex ratios occur. This is indicated by the intermediate character of possibly all four of the collections considered, and also by Hubbs' conclusion (1952: 147-8) that the samples from high pools may be statistically separable from those of low pools. The intergradation between the two forms thus appears to be quite broad.

I believe that many people, myself included, would regard the difference in sex ratio and probable broadness of morphological intergradation between the two forms as suggestive of a single population, rather than two subspecies. In fairness to the latter interpretation, however, two things should be emphasized. First of all, differences in sex ratio among separate populations of a species are by no means unknown. Krumholz (1948), for instance, has shown that the sex ratio of *Gambusia affinis* varies considerably, with females generally in a strong majority. Secondly, there are no strong indications that the deep-water populations of *Gibbonsia elegans velifera* have anything but a one-to-one sex ratio, homogeneously distributed. Thus the aberrant sex ratios and breeding contacts between bathymetrically

separated individuals, if these indeed occur, need involve only the shallow-water form. This more complicated explanation fails to explain the difference in sex ratio between the two forms, however, and the one-population hypothesis does.

The final answer on the nature of these two forms of *Gibbonsia elegans* can only be reached by careful experimental investigation. Morphologically definable habitat forms are common among fishes, and a thorough investigation of this phenomenon would be of immense theoretical and practical interest.

#### FURTHER CONSIDERATION OF THE NOMINAL SUBSPECIES

Although definitive experimental data are lacking, we are not entirely without facts pertinent to the immediate problem of the nominal subspecies of *Gibbonsia elegans*. I believe that there are reasons, in addition to the admittedly inconclusive one of differences in sex ratio, for regarding the two forms not as subspecies but as non-genetic habitat forms. The reasons are as follows:

(1). The morphological differences are small compared to the differences known to have been produced by direct environmental action on genetically similar stocks, and therefore the differences are as readily attributable to direct environmental action as to phylogenetic divergence. The differences in no case consist of anything more than a significant difference between means in the proportions of various bodily measurements to standard length. In "character indices" such as the proportion of head length to caudal peduncle length, the means are never more than two standard deviations apart. Much greater differences have been produced by transplanting stocks of fish from one environment to another. Svärdson (1950) produced striking changes in transplanted stocks of whitefish, one group of transplants being about five standard deviations removed from the parental stock in eye diameter, with other characters affected almost as strikingly. A variety of other fishes have likewise proved to be phenotypically quite plastic, for instance a blenny (Ege, 1942), a stickleback (Heuts, 1947), and a croaker (D. C. Joseph, 1953, paper on "Morphological Variations in a Population of *Bairdiella icistius*, a Gulf of California Scaenid, Spawned in the Salton Sea," presented at meetings of the Western Division, ASIH, on June 17 at Santa Barbara).

(2). The two forms differ only in proportions, not in meristic characters. This is also true of the two other sympatric subspecies pairs in this genus. Allopatric subspecies differences, five cases in all, invariably include meristic differences. This may be coincidence, but statistically it is a strong argument ( $C^2 = 81/3151 = .56$ ;  $p = .018$ ) for believing that the sympatric subspecies are somehow different

from the allopatric ones. A consideration of the time in development at which meristic characters and proportions are determined provides an explanation. Most meristic characters are determined in the egg or larval stage (Tåning, 1952), whereas proportions can be influenced by the environment as late as sexual maturity or later (Martin, 1949). Since *Gibbonsia elegans* probably spawns in varying environments, such as warm bays and the colder coastal waters, we would expect that the meristic characters would be subject to varying environmental influences. Perhaps, however, the fish from these different environments are homogeneously mixed in the larval stage. Perhaps every tidal cycle results in the wholesale removal and replacement of the larvae in bays, and local currents mix the larvae from deep and shallow water. This mixing would obscure any environmental effect on meristic characters, and the fish settling in tide pools would be no different from those settling in deeper waters. Thus the sympatric forms differ only in those characters which can be affected by the environment after the larval stage has been passed, whereas allopatric populations differ in meristic characters as well, the meristic differences being caused by genetic differences or environmental factors acting throughout development, or both.

(3). Population geneticists have raised certain objections to the concept of sympatric speciation. Stebbins (1950: 236-8) summarized these considerations. While I have no inclination to debate upon this matter here, I wish to point out that if these theoretical objections ever have any validity, they would be valid in this case, since the spatial separation of the two forms in coastal waters is extremely slight, and the powers of dispersal of the species, by virtue of its free-swimming larval stage, are probably great.

Even if the habitat forms of *Gibbonsia elegans* should eventually prove to be true subspecies, the fact remains that the only evidence upon which they were originally proposed is the existence of intergrading morphometric differences correlated with habitat. I would like to urge that, in fishes, the mere existence of such differences, whether between closely contiguous habitats or isolated geographic regions, does not by itself constitute evidence of subspecific divergence. Those who persist in recognizing subspecies in such plastic animals as fishes, merely on the basis of such differences, are likely to be proven wrong by future experimental investigations.

#### SUMMARY

The blennioid fish, *Gibbonsia elegans*, is found on the California coast from the lower intertidal to depths of about thirty meters. It is concluded, for the following reasons, that females range more abundantly into shallow water than the males:

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(1). Tide pool collections of fish above the sub-adult size of 50 mm. consist of over 90 percent females.

(2). There are no clear indications of seasonal fluctuations in the proportion of males and females in shallow water.

(3). The proportion of males increases rapidly with increasing depth. Approximately equal proportions of males and females are found over most of the vertical range of the species.

The morphologically definable deep-water and shallow-water forms of this species, which have recently been regarded as sympatric subspecies, are here regarded as non-genetic habitat forms, for the following reasons:

(1). The two forms have different, perhaps complementary, sex ratios.

(2). The morphological differences between the two forms are small compared to differences known to have been produced in fishes by direct environmental influences.

(3). Sympatric subspecies differences in this genus include only those characters which can be affected by the environment relatively late in development. The allopatric subspecies differ in meristic characters which are determined in the egg or larval stage. This can be explained by postulating that allopatric forms constitute separate populations, but that the sympatric forms are derived from a single population of larval fish. Differences arise after the larvae have settled to the demersal habitats.

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## Reproductive Behavior of the Blackstripe Topminnow, *Fundulus notatus*

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THE genus *Fundulus* and other cyprinodontids constitute a conspicuous element of the North American fish fauna. Despite this, there is little published information on their reproductive habits. In order partially to

fill this void, we report here on our studies of *Fundulus notatus* (Rafinesque) made during June and July, 1953. Sexual dimorphism, dominance of certain males, display, and spawning are in general much like that of *Fundulus heteroclitus* (Linnaeus), as described in an excellent paper by Newman (1907).

<sup>1</sup> Both authors contributed equally to this paper, so the sequence of names was decided by the "coin-flip method." Contribution from the Museum of Zoology, University of Michigan.



The observations are based upon field studies at the southern end of Whitmore Lake, Washtenaw County, Michigan, and on laboratory studies of fish brought from the lake to aquaria at Ann Arbor. The aquaria were of two sizes,  $91.5 \times 45.5 \times 38.0$  cms. and  $49.5 \times 30 \times 30$  cms., and the depth of water was maintained between 15 and 20 cms. Unless otherwise stated, the various elements of behavior described were observed a minimum of ten times.

#### SEXUAL DIMORPHISM

As is usual in cyprinodont fishes, there are marked differences between the sexes in color, color pattern, and fin shape. This divergence appears to be related to sex recognition, display, and the reproductive act.

The posterior rays of the dorsal and anal fins are elongated in the male so that these fins appear much larger than the corresponding rounded fins of the female. In general in the male, the dorsal, anal and pelvic fins are bright yellow, and the caudal and pectoral fins are pale yellow. Little or no yellow appears in the fins of the female. The color of the male's dorsal fin is divided into three bands: an outer edge of opaque white; a middle dusky-gray band about one-third the width of the fin; and a lemon-yellow basal band, about two-thirds the width of the fin, which is sprinkled with large irregular black spots. The dorsal fin of the female shows a similar division of color, with a few large gray spots, a slight tinge of yellow, and a partial white opaqueness. The anal fin in the male is marked also by three major bands: an outer narrow band of lemon yellow; a slightly wider dusky-gray band; and a basal band one-half the width of the fin, which is cloudy-white except for a narrow outer margin of yellow. The basal band has large, scattered black spots. The anal fin of the female is characterized by a few dusky-gray spots, an opaque white appearance and sometimes a tinge of yellow.

The caudal fin of the male has larger black spots and a little more yellow than does that of the female. The male's pelvic fins are lemon yellow, more intense on the outer edge, whereas those of the female are white and partially transparent. In both sexes the pelvics are dusted with small melanophores. The pectoral fins are similar in both sexes, except for a slight yellowness and duskiess on the inter-

radial membranes of the male. The large black or gray spots that appear on the various fins seem to consist of numerous minute melanophores.

Both sexes have a black stripe from the mouth, through the eye, to the base of the caudal peduncle, its width slightly less than the diameter of the eye. Above and below this stripe in the male is a series of vertical dark projections. The upper half of the body is usually olive, whereas the belly is tinged with yellow in the male, and white in the female. A blue sheen, more extensive in the male, appears below the midlateral stripe in both sexes. There are other minor sexual differences such as the blue chin and the yellow branchiostegal membranes in the male, which are white in the female.

We found no contact or pearl organs in the male, such as those described by Newman for *Fundulus heteroclitus*, *F. majalis*, and *F. diaphanus*. From his studies of these species, Newman formed the impression that males were less numerous than females. Our seine hauls and observations on *F. notatus* indicate approximately a one-to-one sex ratio. Nevertheless, by the end of the spawning season, males were much more abundant than females in the area of our study; perhaps because most of the females, then spent, had migrated. There is no obvious sexual difference in size, except during the breeding season when the abdomen of the female is distended with eggs.

#### SPAWNING SEASON

In the winter, *F. notatus* stays in the deeper water, apparently in bottom vegetation. On March 1, 1953, with a thin veneer of ice near the shore of Whitmore Lake, a few specimens were seined from the heavy organic debris of the plant zone, in about four feet of water. This zone is on the edge of a sharp drop into deeper water. On March 21, 1953, a few were seined in the deeper plant zone and in the shallow shore zone. Two years before, on April 30, 1951, the fish were common along the shore zone. From this evidence it appears that *F. notatus* migrates from deep water late in March or early in April to the shallow shore zone, where the fish assume a surface swimming habit typical of many cyprinodonts. Reproductive activity begins at least by early May,



although some females seined on April 26 had ripe eggs. The first eggs are laid sometime before the end of May and, by the third week of August, none of the few females found retained eggs. Chidester (1920) stated that *F. heteroclitus* breeds from April to July in New Jersey. A breeding season of three months duration is quite extensive when compared to most other fishes of the north-temperate region.

#### TERRITORIALITY AND DISPLAY

Under certain conditions, males and females of *Fundulus notatus* exhibit aggressive behavior in both the field and laboratory. A clear picture of the territory and dominance is not apparent from our studies. We believe this to be due in part to the weakly defended and elastic territory of both sexes.

Observations and seine hauls show that the fish typically travel in pairs along the shore. The male usually follows slightly below and behind the female. This pair activity occurs within an area six to twelve meters long, parallel with and close to the shore. Somewhere in the middle of this territory is a small cove or protected pocket to which the female returns, usually accompanied by a male. Although several pairs are frequently seen in the same area, they often do not molest each other. Sometimes, however, when the pairs closely approach, one male vigorously chases the other male away. The attacked male retreats rapidly, often breaking the surface in what seems to be a series of skips. In such contacts, one pair appears to be in the periphery of its territory, while the pair with the dominant male is near the middle of its territory. If a larger lone male approaches a pair, he quickly chases the smaller male away. If, on the other hand, the female is left alone in her area and another female approaches, the intruder is driven away. This aggressive behavior by the female when unpaired was noted also several times in the aquaria. When paired, the female never shows pugnacious activity in the field. She sometimes will leave the male to enter the thick vegetation beside the shoreline, where the male no longer follows her. After seemingly "resting" and feeding for a short period, she returns to her open area where she is soon followed by a male. The female apparently can lead the male almost anywhere in her area,

except close to the shoreline in the dense emergent vegetation.

The males swim in an apparently limited area, six to twelve meters long, parallel to the shore and not more than four meters from the shoreline or from the line of emergent aquatic vegetation. Our field observations indicate that the males also remain in one area, although they are possibly less restricted in their movements than the females. The areas overlap broadly with no definite line between them. One male will chase other males from the center of his area, but when paired he will permit them to enter more freely. In two observations a minnow, a schooling *Notropis*, followed in midwater below a male *Fundulus* but the minnow was not attacked. These observations seem to indicate incipient pair formation and incipient territoriality by both sexes. Newman said of *F. heteroclitus*, "although an active male may pursue a female or another male for considerable distance, he soon returns to the neighborhood over which he seems to exercise authority." No statement was made about the normal behavior of the female. Because of the absence of a precise territorial boundary, we were unable to distinguish clearly between home range and territory.

In the limited confines of the aquarium, the behavior described above is disrupted. When two or three individuals of each sex are placed in a tank, the largest male is immediately dominant. This male spawns with all the females, but if he is occupied with one female, another male may spawn in the opposite end of the tank. After frequently turning sideways, the largest male darts at his opponent who swims rapidly away. Often, the smaller male retreats from this rival without a chase. This is in contrast to Newman's statement that in *F. heteroclitus* brilliant coloration rather than size determines dominance. Twice, smaller males were seen to defend a small area in one corner of the larger aquarium. In one tank, males and ripe females chased spent females. In the same experiment a ripe female occasionally bit at a male following her. Rarely, a ripe female may be attacked by a male if she is in his way when he chases another male.

Three times we observed prolonged fights between males of about the same size, and we were able to induce contests with a mirror.

The males take positions parallel to each other, facing in opposite directions, with all the fins except the pectorals stiffly spread and with the throat area expanded. Then each makes abrupt dashes and nips at the caudal region of his opponent. The abrupt dashes start with the caudal bent about 90 degrees, which is similar to the position of this fin during the spawning act. In so doing, the antagonists turn in a circle, and the larger male always was the winner. There is no evidence that the male displays the fins in front of the female.

#### COURTSHIP AND SPAWNING

There is little that can be called courtship in *Fundulus notatus*. Usually the male follows below and behind the female, although he may move ahead at times. Often the male wanders a few feet and then returns. This quiet swimming is in contrast to the "impetuous" chasing of females by the male of *F. heteroclitus*, as described by Newman. When the female of *F. notatus* swims slowly or stops, the male often moves forward or upward beneath her, with his head slowly moving up and down. The significance of this characteristic head "dipping" is unknown. It has been observed only when the fish are paired, and usually when the male is out of view of the female. Neither "belly flashing" of the female, nor "head butting" of the male, noted by Newman in *F. heteroclitus*, was observed in *F. notatus*. That the female may try to attract the male is indicated by a random observation on May 27, 1951. Four times a female left a side pocket near shore to intercept groups of cruising males. Each time she returned with a male who followed her for a short time and then swam away.

When the female is ready to spawn, she goes to some algae or other plants. The behavior that stimulates the male's spawning reaction seems to be the close presence of a female beside or on top of some vegetation well below the surface of the water. Frequently, males would try to spawn with females feeding in the algae on the bottom of the tank, but the females always swam away. It is obvious from this that the female determines the time and place to spawn. When the spawning position is assumed, both sexes rapidly vibrate for one or

two seconds. The throats are expanded. The vibration is ended with a flip of the caudal fin, usually by the male, which throws the single egg into the algae. The egg is frequently released from the female by the vibrations, but it often remains attached to her by a mucous thread until the final flip that throws it into the vegetation. On several occasions, females that were alone in a tank laid eggs, sometimes assisted by another female who vibrated side by side with her. In this situation it is difficult for the female to detach the externally attached egg. When the female is through spawning, she swims rapidly to the surface. The vibrations are initiated either by the male or female, although more often the male starts the vibrations. According to Newman, the vibration is initiated only by the female in *F. heteroclitus*.

By the end of the spawning season, many abnormal situations were observed in the aquaria. Twice the mating position was reversed, the head of one fish placed against the tail of the other. Several times the male approached his partner too high on her side, and although an egg was extruded it remained hanging from the female. Once a female was observed spawning by herself, although a male was courting her all the time. In at least four observations two males tried to spawn with a female at the same time, with one male on each side of the female or both males on her same side.

In the spawning position (Fig. 1), the dorsal and anal fins of the male are folded over the corresponding fins of the female. The dorsal fin of the female may bend toward or away from the male. The body assumes an S-shape, with the caudal fin at a right angle to the body. The caudal fins may be bent away from or toward the algae. In contrast to *F. heteroclitus*, the bodies are separated anteriorly and the pectoral fins maintain balance. The pelvis of the male are either pressed against the female's body or against his own body (based on five observations). Neither the dorsal, anal nor pelvic fins were hooked under the corresponding fins of the female, as Newman reported for *F. heteroclitus*. The fish spawned sideways against the plants or sideways down onto the plants at the bottom. In the only instance of spawning observed in the field, one female spawned 30 times in twenty minutes in the

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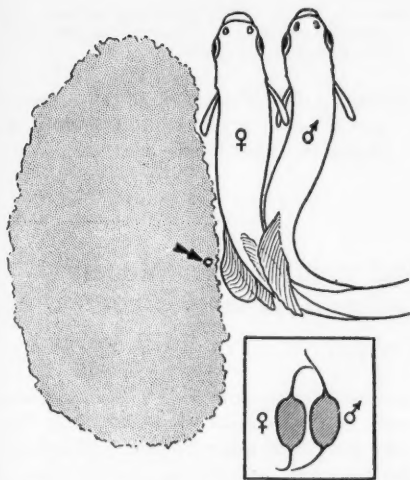


Fig. 1. Spawning act of *Fundulus notatus* against a mass of algae. Arrow indicates an egg. Diagrammatic inset is a cross section to show the position of the dorsal and anal fins.

center of her area with her side turned down or side-ways onto a patch of *Chara* and other algae. Three males were involved separately in the process.

In the laboratory, eggs were readily eaten by the females and non-dominant males. The dominant male slowed this process somewhat by chasing males and by trying to spawn with females when they went down to the algae to eat the eggs. Because of a shortage of food and/or space in the aquaria, females frequently fed on the bottom in the algae. Under natural conditions, the eggs are not likely to be eaten for at least three reasons: (1) the adults are well scattered over a wide area and probably do not find many eggs; (2) if the female found the eggs, a male would try to mate with her and she would swim away; and (3) perhaps most important of all, the fish feed almost exclusively at the surface in nature.

There is some evidence that the females lay 20 to 30 eggs individually over a short period and then wait, perhaps several days, until more eggs ripen. The appearance of the ovary and the one observation in the field indicate this. Females brought into the laboratory laid eggs within a few hours, but the remaining eggs in the ovary did not enlarge and ripen.

#### SUMMARY AND COMPARISON OF THE BREEDING BEHAVIOR OF

##### *Fundulus notatus* AND *F. heteroclitus*

Traits that the two species have in common are as follows:

1. The males have elongate anal and dorsal fins, an extensive blue sheen, prominent vertical bars, and brilliant pigmentation.
2. They breed over a period of three to four months.
3. They have a definite migration.
4. The males maintain a loosely delimited territory.
5. In a mixed aquarium group one male becomes dominant.
6. The fighting posture is similar.
7. Occasionally females attack males.
8. There is little courtship.
9. When in pairs, the male follows slightly below and behind the female.
10. When the female goes to the bottom against an object, this stimulates the male to attempt to spawn with her.
11. They eat their eggs in aquaria.

Traits in which the two species differ are as follows:

1. No contact or pearl organs appear in *F. notatus*.
2. *F. notatus* exhibits "head dipping," whereas *F. heteroclitus* exhibits "belly flashing" and "head butting."
3. A final flip, which throws the single egg deep into the plants, follows the vibration in *F. notatus*, but apparently does not take place in *F. heteroclitus* when laying eggs in the mud.
4. Although the spawning position is generally the same in both species, the male of *F. notatus* folds his fins over, rather than hooks them under, the corresponding fins of the female. The head regions of the male and female in *F. notatus* are not in contact as in *F. heteroclitus*.
5. In *F. heteroclitus*, the anal fin is used for support during spawning. In *F. notatus*, the body against the plants and the pectoral fins are used for support.
6. *F. notatus* lays a single egg at a time, whereas *F. heteroclitus* apparently deposits more than one, although this is not clearly stated in Newman's paper.

Other characteristics of *F. notatus* are as follows:

1. Females have a small hiding place close to shore within a wide range, which is used to escape from males and sometimes is defended against lone females.
2. Both the male and female may vibrate independently.
3. Individuals of two pairs frequently change partners.

We wish to express our gratitude to Reeve M. Bailey, Robert R. Miller, and Carolyn P. Winn for many valuable suggestions in the prepara-

tion of the manuscript. William Brudon helped plan and ink the figure.

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## A Rediscovered Cyprinid Hybrid from Western Montana, *Mylocheilus caurinum* × *Richardsonius balteatus balteatus*

GEORGE F. WEISEL

DURING the explorations and surveys made in 1853-5 to ascertain the most practicable route for a railroad to the Pacific, one of the naturalists collected a cyprinid near Fort Vancouver, Columbia River, that was subsequently described and given the name of *Cheonda cooperi* by Charles Girard (1856: 207). The only known specimen of the type species of *Cheonda* is deposited in the U. S. National Museum (USNM No. 238). Besides the original report by Girard, this fish was described also by Suckley (1860: 362-63), illustrated in the same volume (Plate LXIII, figs. 1-5), and by Jordan and Evermann (1896: 236).

Although the fish fauna of the lower Columbia River has been studied extensively since Girard's time, no fish closely resembling *Cheonda cooperi* has been taken. Schultz and Schaefer (1936: 8-10) had further measurements made of the specimen in the National Museum and concluded that it must be a hybrid between *Mylocheilus caurinum* and *Richardsonius balteatus balteatus*. Miller (1945: 104) examined the fish later and agreed with them.

Nearly a hundred years after the unique "*Cheonda cooperi*" was taken, another one was captured in the upper reaches of the Columbia River (Pl. I). This fish was caught in a gillnet set by Royal B. Brunson and Richard G. Bjorklund at about 10 meters depth off the south point of Yellow Bay, Flathead Lake, Montana, in the summer of 1952. Dr. Brunson has since made many collections in Flathead Lake, but no new specimens of the hybrid have been taken. I agree with Schultz and Schaefer that it must occur rarely. We netted

another intergeneric hybrid, *Mylocheilus caurinum* × *Ptychocheilus oregonense*, from the lake with remarkable frequency (Weisel, in press).

Our specimen of the rediscovered hybrid closely resembles the early descriptions of *Cheonda cooperi*, and except for greater body depth and narrower caudal peduncle, it is very like the illustration of this fish in Suckley's report. It also conforms in most respects to the measurements and counts given by Schultz and Schaefer. They expressed lengths in hundredths of the standard length. With their figures in parentheses, the comparison of the two fish is as follows. Standard length, 185 (172); length of head, 23.7 (24.0); diameter of eye, 5 (5); length of snout, 7.0 (7.4); length of lower jaw, 6.8 (8.7); greatest depth of body, 27.5 (24.2); least depth of caudal peduncle, 8.3 (8.2); number of anal rays, 2-10½ (2-11½); dorsal rays, 2-7½ (3-8½); pelvic rays, 1-9 (1-9); scales in lateral line to end of hypural plate, 64 (63); scales below lateral line, 10 (7); scales above lateral line, 12 (12).

The length of the jaw and the number of scales below the lateral line present the only significant data not in accord. Our specimen seems to have a much smaller mouth, not only when compared in measurement, but also when compared with Suckley's illustration. It has more scales below the lateral line than the holotype. However, I find a higher count for this character in *Mylocheilus* and *Richardsonius* than given by Schultz and Schaefer for the same species.

There is little doubt that our specimen is a hybrid between *M. caurinum* and *R. balteatus*.

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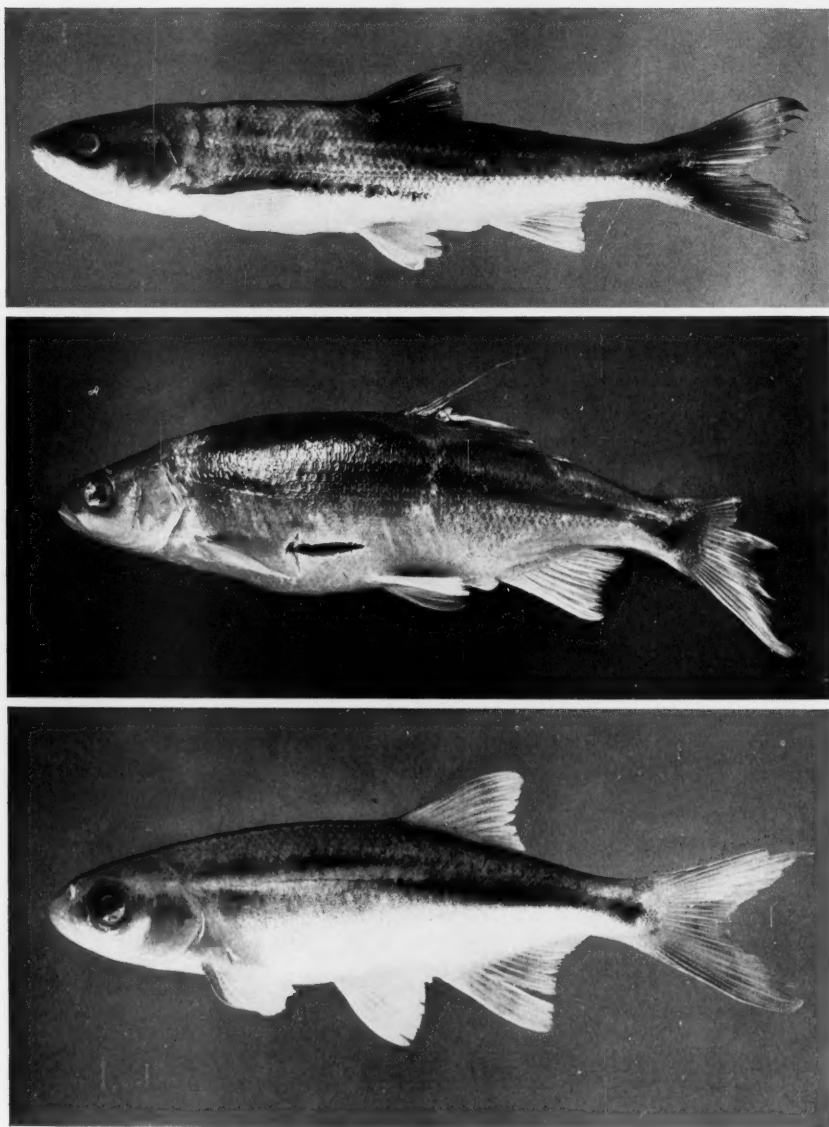
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Above. *Mylocheilus caurinum*, 195 mm. in standard length.

Middle. Hybrid, *Mylocheilus caurinum*  $\times$  *Richardsonius balteatus balteatus*, from Flathead Lake, Montana, 185 mm. in standard length.

Below. *Richardsonius balteatus balteatus*, 85 mm. in standard length.

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Only one fish of its kind has been taken although extensive collections have been made in the area; both parental species are abundant in the lake; and it is intermediate in most characters that contrast the assumed parents. Besides the two parental species, the only other cyprinid that inhabits Flathead Lake is *Ptychocheilus oregonense*. We have already found and described hybrids of *M. caurinum*  $\times$  *P. oregonense* from this lake and of *P. oregonense*  $\times$  *R. balteatus* from a warm spring in the same drainage (Weisel, in press). The specimen is quite unlike these hybrids or any known valid species of cyprinid.

In a series of papers, Hubbs and coauthors (1932-53) have demonstrated that hybrids are intermediate in the majority of characters that differentiate their parental species. When put to this test, our identification of the hybrid is confirmed.

The comparisons that follow deal mostly with characters that are measurably unlike in the two reputed parents. These are of primary importance in identifying the hybrid. However, characters that are alike in the two parents are of definite significance and should not be neglected. Theoretically, most of these characters in the hybrid should come within the ranges set by its parents. Counts and measurements in which *Mylocheilus*, *Richardsonius*, and their supposed offspring are not significantly dissimilar include numbers of rays in the pelvic fin, in the pectoral fin, and in the caudal fin, width of isthmus, internarial width, interorbital width, depth of caudal peduncle, and length from snout to origin of anal fin.

#### COMPARISON OF THE HYBRID WITH ITS PUTATIVE PARENTS

Unless otherwise indicated, counts and measurements were made according to procedures outlined by Hubbs and Lagler (1947: 8-15). Ten adults of each parental species from Flathead Lake were used in all calculations.

**SIZE AND COLOR.**—In general body form, the Columbia River chub, *M. caurinum*, is a more slender and terete fish than the rather deep, somewhat compressed reidside shiner, *R. balteatus*. The hybrid resembles the shiner most in this respect. The proportionate measurement of greatest body depth to standard length shows the hybrid to be much deeper than

chubs but only slightly less so than shiners (Table I).

Mature chubs range from 165 to 285 mm. in standard length. Adult shiners are 60 to 110 mm. long. The largest shiner recorded for the upper Columbia drainage is 113 mm. (Weisel and Newman, 1951: 188). The hybrid with a standard length of 185 mm. can be considered intermediate in size.

Both of the parental species are brightly colored for cyprinids. The chubs possess two dusky lateral stripes separated from each other and from the dark dorsum by narrow light bands. The dorsal stripe continues from the operculum to the caudal base, and the ventral one to above the origin of the anal fin. There is a blotch of red at the angles of the jaw and lighter red along the cheek, around the base of the pectorals, and on the side of the body for a varying distance. The shiners have but one dark lateral stripe that follows the lateral line and is more intensified posteriorly. They have a striking bright-red wash just behind the operculum, at the base of the pectorals, and as a band narrowing towards the anal fin. A metallic gold half-moon is located below the eye and the same color is evident on the sides below the lateral line. The hybrid gives the impression of resembling the shiners more than the chubs in color (Pl. I). Just above the lateral line is a dark stripe that continues from the posterior margin of the operculum to the caudal base. It is separated from the dark olive back by a light tan band. A red wash is evident around the pectoral base and on the preoperculum, but there are only a few erythrophores at the angles of the jaw. There is also a gold tinge to the operculum. The chin, throat, lower sides, and belly are a cream color. The hybrid has no melanophores on the lower jaw, but does have a few on the posterior parts of the upper jaw. For this particular color pattern in the parents, shiners have melanophores on both jaws whereas they are lacking on the jaws of the chubs.

**HEAD.**—Proportionately, the head of chubs is shorter than that of the shiners, the snout longer, and the jaw and eyes are smaller. The hybrid is intermediate in these characters (Table I). The chub's jaw reaches only to below the internarial septum, is not oblique, and is overhung by the snout. A curved crease

TABLE I  
PROPORTIONATE MEASUREMENTS OF THE HYBRID,  
*Mylocheilus caurinum*  $\times$  *Richardsonius balteatus*,  
AND THE PARENTAL SPECIES

Ten of each parental form were measured. The ranges are listed for each item, and the averages appear below these in parentheses

Character	<i>M. caurinum</i>	Hybrid	<i>R. balteatus</i>
Standard length, mm.	172-256 (200.4)	185.0	73-93 (82.0)
Standard length Depth	3.9-4.8 (4.48)	3.63	3.4-3.6 (3.49)
Standard length Head	4.1-4.4 (4.27)	4.20	3.9-4.1 (4.03)
Standard length Snout to dorsal origin	1.8-2.0 (1.93)	1.78	1.6-1.7 (1.65)
Standard length Posterior dorsal base to caudal origin <sup>1</sup>	2.4-2.7 (2.56)	2.89	3.5-3.8 (3.62)
Standard length Posterior anal base to caudal origin	4.9-6.2 (5.43)	5.96	6.5-8.0 (7.2)
Standard length Snout to pelvic origin	1.8-1.9 (1.88)	1.96	2.0-2.1 (2.04)
Standard length Pelvic origin to caudal origin	1.9-2.0 (1.93)	1.94	1.7-1.9 (1.83)
Head Orbit	5.0-5.6 (5.37)	4.63	3.2-3.5 (3.37)
Head Jaw length	3.8-4.4 (4.09)	3.52	2.8-3.3 (2.98)
Head Snout to eye	2.9-3.2 (3.07)	3.38	3.5-4.0 (3.73)

<sup>1</sup> The caudal origin is taken as that point where the lateral line intersects the crease formed at the origin of the caudal when the fin is flexed.

runs anteriorly and dorsally from the angle of the jaw. All of the *Mylocheilus* have a small but well defined barbel near the tip of each maxillary. The jaw of shiners, on the other hand, reaches to below a point between the nares and the orbit, or as far posterior as the orbit. The mouth is oblique, is not overhung by the snout, and lacks the crease and barbels

present in chubs. The hybrid's jaw reaches to between the nares and the orbit, is slightly oblique, barely overhung by the snout, and has a poorly developed crease running forward from the angle of the jaw. This intermediacy is evident even for the barbels, for there is a small one on the right maxillary tip only.

**POSITION OF DORSAL AND PELVIC FINS.**—The dorsal fin of the chub is slightly anterior in position compared to that of the shiner (Table I). In two proportionate measurements, from the snout to the origin of the dorsal and from the posterior base of the dorsal to the hypural plate, the hybrid shows intermediacy.

The pelvics of the chub are a little more posterior than in the shiner. This and the anterior position of the dorsal place the origin of the pelvics just posterior to a vertical line from the origin of the dorsal. In comparison, the pelvics of shiners are well anterior to the dorsal's origin, and those of the hybrid are barely anterior.

**SCALES AND FIN RAYS.**—There is no marked difference in the appearance of scales from chubs and shiners. The number of radii vary greatly in both and are on the posterior field only. The hybrid's scales are similar. They possess two clear annuli.

As to numbers of scales, the chubs have higher counts than shiners in all rows except that before the dorsal, in which count there is some overlap in the two species (Table II). The scale-row counts on the hybrid are intermediate. The lateral-line count is almost exactly so.

The lateral line of chubs is only slightly decurved, and this is from the operculum to below the origin of the dorsal. In shiners the line is decurved more gradually and the curved portion reaches to below the posterior base of the dorsal. The hybrid's lateral line is more abruptly curved than in shiners but not so much so as in chubs, and it straightens at a point below the middle of the dorsal.

Almost invariably, *Mylocheilus* has 8 rays in both its dorsal and anal fins, whereas *Richardsonius* from Flathead Lake has 10-11 in the dorsal and 15-18 in the anal. The hybrid possesses 8 rays in the dorsal, but the anal number of 11 gives it a higher count than chubs, yet fewer than shiners. I have counted the anal rays of 943 *R. b. balteatus* and none had as few

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as 11 anal rays and only one had as low as 12. The mean was 15.

**PHARYNGEAL TEETH AND GILLRAKERS.**—In 47 sets of pharyngeal arches examined from chubs, 36 had the dental formula of 1,5-5,1; 6 had 1,4-5,1; 2 had 1,4-5,0; and there were one each with 1,5-4,1, 1,5-5,0, and 1,5-6,1. In adult chubs the dorsal teeth of the inner row are of the molar type. Shiners generally have the formula of 2,5-4,2 and the teeth are sharp and slightly hooked. The hybrid's tooth count is 2,5-5,2. The teeth, especially the dorsal ones of the inner row, are sharp and hooked. None of them has a grinding surface.

The gillrakers of both chubs and shiners are small and liable to be obscured with soft tissue and mucus. For a more accurate count, the first arch on the left side of each fish was removed and dried. Inasmuch as the number of rakers in the anterior and posterior rows gen-

erally are not the same, both rows were taken into account (Table II). There is a definite tendency for chubs to have more rakers than do shiners, in both rows and in the upper limb of the arch as well as in the lower. The hybrid raker formula is 3 + 8 for the anterior row and 4 + 10 for the posterior row which places it in the upper ranges of *Mylocheilus*. The dried gillrakers of the hybrid and of the two parental species are similar in size and shape. They are sharp, slightly hooked, weak, and probably somewhat deciduous.

**ACKNOWLEDGMENTS.**—I am indebted to Dr. Robert R. Miller of the University of Michigan for bringing the literature on *Cheonda cooperi* to my attention, and to Dr. Royal B. Brunson of the University of Montana for collecting and saving the hybrid.

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TABLE II

MERISTIC CHARACTERS OF THE HYBRID, *Mylocheilus caurinum* × *Richardsonius balteatus*, AND THE PARENTAL SPECIES

Counts were made on ten of each parental form. The ranges for each item are listed, and the averages appear below these in parentheses

Character	<i>M. caurinum</i>	Hybrid	<i>R. balteatus</i>
Scale rows:			
Total in lateral line . . .	70-79 (75.5)	68	58-61 (59.9)
Above lateral line . . . . .	14-15 (14.3)	12	11-13 (12.1)
Below lateral line . . . . .	10-12 (10.7)	10	8-9 (8.6)
Before dorsal . . . . .	37-44 (39.6)	39	41-50 (46.2)
Dorsal rays . . . . .	8	8	10-11 (10.2)
Anal rays . . . . .	8	11	15-18 (16.1)
Gillrakers on first arch:			
Upper limb anterior row	2-3 (2.8)	3	1-2 (1.9)
Lower limb anterior row	6-9 (7.9)	8	5-6 (5.1)
Upper limb posterior row . . . . .	2-4 (3.3)	4	0-3 (2.1)
Lower limb posterior row . . . . .	9-11 (10.1)	10	7-9 (7.4)

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## Pleistocene Fishes of the Berends Fauna of Beaver County, Oklahoma

C. LAVETT SMITH

**D**URING the past few years intensive work in southwestern Kansas and northwestern Oklahoma has yielded a series of vertebrate faunas which give us considerable information about the climate of the Great Plains during Pliocene and Pleistocene times. From Pleistocene deposits there have been recovered a succession of cool and warm faunas which can be tentatively correlated with glacial advances and retreats (Hibbard, 1953). Most of these faunas are predominantly mammalian. The Berends fauna is the first large fish fauna that has been recovered from Pleistocene deposits anywhere in the United States and it contains enough species to enable the zoogeographer to establish both northern and southern limits of the comparable Recent fauna.

The first published report on the Berends fauna was that of Rinker and Hibbard (1952), in which they described a new beaver and listed several other associated vertebrates. This paper was based upon material collected prior to and during the summer of 1951. In 1952, Dr. C. W. Hibbard again visited the area, accompanied by Michael O. Woodburne, William G. Melton Jr., and the author, and collected from surface exposures additional fish remains and a jaw of the vole *Microtus pennsylvanicus* (Ord). During the summer of 1953 the University of Michigan Museum of Paleontology field party, under Dr. Hibbard's direction, worked the deposits using the washing technique described by Hibbard (1949). A little more than one and one-half tons of the matrix was washed and from this amount most of the material described in this paper was recovered.

This fauna takes its name from the Berends sand draw along which the deposits are exposed; it was referred to as the "Unnamed fauna (Illinoian?)" by Hibbard (1953: 389). The fauna consists of abundant remains of mollusks (D. Taylor, 1954) and vertebrates.

### THE BERENDS FISH FAUNA

The exposures from which the fossils were collected lie in the southeastern corner of Sec. 6, T5N, R28ECM, near the Gate Ash Pit, 4½ miles north and nearly 1 mile west of Gate, Beaver County, Oklahoma. The material is considered to be comparable to the lower part of the Kingsdown formation and is referred to the Illinoian? glacial stage of the Pleistocene by Rinker and Hibbard (1952: 99). The matrix consists of sand and sandy silts, dark to ash grey and buff in color. These sediments were laid down in a lake that filled one of the large sinks that developed as a result of the collapse of some of the underlying Permian beds. This lake was probably populated by fish at a time when it was connected with the early Cimmaron River.

All specimens are deposited in the University of Michigan Museum of Paleontology (UMMP). The drawings are by the author.

### CLASS OSTEICHTHYES

#### LEPISOSTEIDAE

##### *Lepisosteus* sp.

(Fig. 1 A, D)

Referred material: UMMP No. 31150, 1 scale 12.4 mm. in length and 5.3 mm. in maximum width.

Because of the great variation in gar scales, depending on the age of the fish, position on the body, etc., it does not seem possible to identify this scale to species. The present-day distribution of the family is in warm-temperate and tropical America. The genus reaches its northern limit in the upper Missouri valley of Montana and North Dakota, the Red River of the North in North Dakota and Minnesota, the upper Mississippi valley in Minnesota and Wisconsin, the Great Lakes drainage other than Lake Superior, and in the St. Lawrence River drainage to Quebec and Vermont. Gars are found southward to the Lake Nicaragua basin, Central America (Miller, 1954). They occur chiefly in larger streams and lakes.

#### ESOCIDAE

##### *Esox masquinongy* Mitchell

(Fig. 1 B - C)

Referred material: UMMP Nos. 31151-52, 3 complete teeth and a fragment of a fourth, measuring 11.5 mm., 7.7 mm., 3.3 mm. and 9.9 mm.

These teeth are identified on the basis of their shape. They are blunter and more compressed than are those of the other large esocids. In its Recent distribution the muskellunge is the most restricted of all of the forms found in the Berends fauna. It now occurs from Lake Champlain and the St. Lawrence River north to Lake Abitibi, west to Lake of the Woods, south to Iowa, Illinois, and Indiana, and in the Ohio and Tennessee River basins from western New York to North Carolina and Tennessee. The muskellunge usually inhabits lakes and quiet, clear rivers.

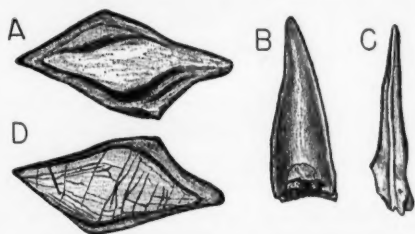


Fig. 1. Scales and teeth of *Lepisosteus* and *Esox*. A, Internal surface of scale of *Lepisosteus* sp. (UMMP No. 31150). D, External surface of same. B, Lateral surface of tooth of *Esox masquinongy* (UMMP No. 31152). C, Anterior surface of same.

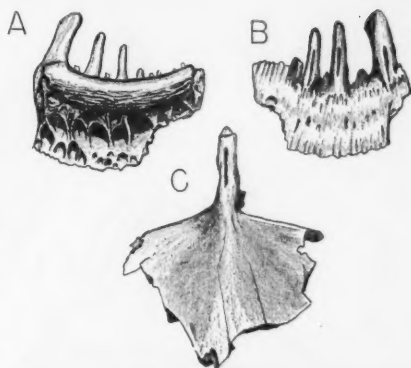


Fig. 2. Remains of *Calostomus commersoni*. A, Antero-lateral surface of left pharyngeal arch (UMMP No. 31161). B, Postero-medial surface of same. C, Dorsal view of mesethmoid (UMMP No. 31160).

#### CATOSTOMIDAE

##### *Calostomus commersoni* (Lacépède)

(Fig. 2)

Referred material: UMMP No. 31159 (part), 2 opercular fragments; UMMP No. 31159 (part), 1 large fragment of parasphenoid; UMMP No. 31160, 1 nearly perfect mesethmoid; UMMP No. 31161 and 31159 (part), 6 pharyngeal-arch fragments.

All of these bones agree very closely with the corresponding structures of the Recent white sucker. The species is now found from the upper Mackenzie River basin to the Labrador Peninsula and southward to the Saluda River in South Carolina. In the Mississippi River drainage it occurs south to the Tennessee River system and in the uplands of northern Arkansas and northeastern Oklahoma. It is absent south of north-central Kansas but westward it inhabits the headwaters of the Arkansas, Canadian and Pecos rivers. According to Reeve M. Bailey, the limiting factor in its distribution is probably the presence of suitable gravel areas for spawning. White suckers are found in both clear and turbid waters.

#### CYPRINIDAE

Four species of minnows are represented in the collection but the material is so fragmentary that the identifications given are tentative only, pending the collection of additional fossils. Although cyprinid pharyngeal teeth



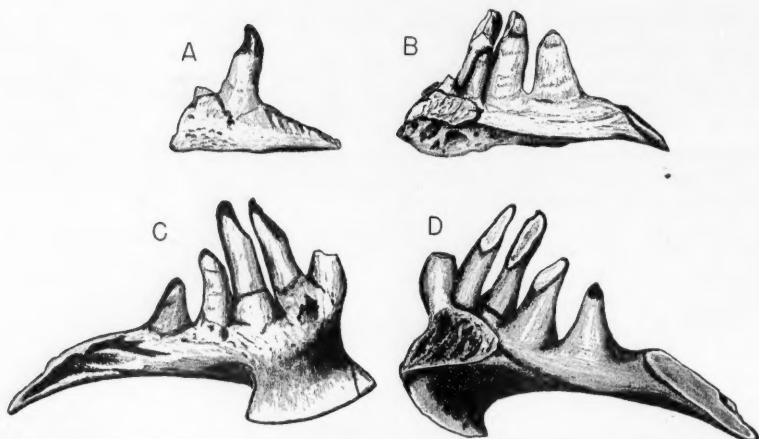


Fig. 3. Pharyngeal teeth and arches of Cyprinidae. A, Ventral view of pharyngeal arch of *Semotilus* cf. *atromaculatus* (UMMP No. 31155). B, Dorsal view of arch of ?*Semotilus* sp. (UMMP No. 31145). C, Ventral view of right arch of *Notemigonus crysoleucas* (UMMP No. 31149). D, Dorsal view of same.

have been commonly used as taxonomic characters, most of the emphasis has been placed upon the number and arrangement of the teeth rather than on the character of the arch itself. Moreover, pharyngeal teeth are highly adaptive and probably reflect food habits more than they do phylogeny.

The terminology used here is that of Chu (1935: 83-5).

*Notemigonus crysoleucas* (Mitchill)

(Fig. 3 C - D)

Referred material: UMMP No. 31149, 1 right pharyngeal arch, lacking the posterior edentulous process; UMMP No. 31148, 1 right dentary.

The pharyngeal arch has five teeth in the inner row and none in the outer; three of the five teeth are complete. Following are the measurements of the specimen in mm.: Length of anterior limb, 3.1; length of anterior edentulous process, 1.7; length of pharyngeal arch 4.0; and width of pharyngeal 1.3. The dentary has a maximum length of 6.3 mm. and is 1.2 mm. deep at the symphysis.

The golden shiner now ranges from the southern half of Lake Winnipeg eastward to New Brunswick and south to Texas. It is usually found in lakes, ponds, and sluggish streams, where vegetation is moderate or abundant.

*Semotilus* cf. *atromaculatus* (Mitchill)

(Fig. 3 A)

Referred material: UMMP No. 31155, 1 fragment of left pharyngeal arch.

Only the most anterior tooth is left on the pharyngeal and identification is made on the basis of the shape of this tooth and of the arch itself. The anterior edentulous process is 4.7 mm. long and the tooth is 3.9 mm. in length. Creek chubs are today found in rather small clear streams from Montana and the Red River of the North east to the Gaspé Peninsula, and south on both sides of the Appalachians to northern Florida and eastern Texas. The species also occurs in the Ozark uplands and in the headwaters of the Arkansas and Pecos rivers of Colorado and New Mexico. Like the white sucker, the limiting factor is probably suitable spawning conditions.

?*Semotilus* sp.

(Fig. 3 B)

Referred material: UMMP Nos. 31145-46, 2 fragmentary right pharyngeal arches.

These remains do not seem to agree with comparable parts of any minnow of eastern United States. The smaller arch is quite fragmentary but the larger one (No. 31145) lacks only the posterior edentulous process. The pharyngeal bone is heavy like that of *Semo-*

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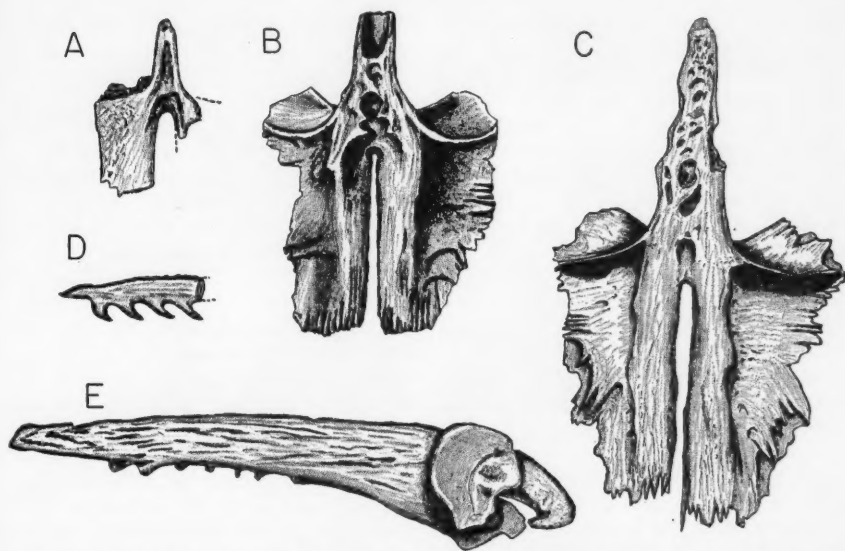


Fig. 4. Skull bones and pectoral spines of *Ictalurus*. A, Dorsal view of supraoccipital, 6.7 mm., of a young individual of *Ictalurus melas* (UMMP No. 31165). B, Dorsal view of supraoccipital, 10.9 mm., of a larger individual of *Ictalurus melas* (UMMP No. 31164). C, Dorsal view of supraoccipital, 18 mm., of a large specimen of *Ictalurus melas* (UMMP No. 31163). D, Portion of pectoral spine, 5 mm. long, of *Ictalurus punctatus* (UMMP No. 31156). E, Left pectoral spine, 20 mm., of *Ictalurus melas* (UMMP No. 31167).

*tilus atromaculatus*, but the anterior edentulous process is very short, which suggests that the head may have been short and broad. The dental formula is -4.2. The measurements of the larger specimen (in mm.) are as follows: Length of anterior limb, 6.0; length of anterior edentulous process, 2.8; width of pharyngeal bone, 2.4; length of pharyngeal bone, 8.6; lengths of remaining teeth in the inner row, 2.2, 2.4, and 2.9; and length of remaining tooth in the outer row, 1.6. In the absence of sufficient material, it would be unwise to assign a new name to this form.

#### *Incertae sedis*

There is one additional fragment of the pharyngeal bone (UMMP No. 31147) of a minnow which is not conspecific with any of the above cyprinids. All of the teeth have been lost and I am unable to make an identification.

#### ICTALURIDAE

##### *Ictalurus punctatus* (Rafinesque)

(Fig. 4 D)

Referred material: UMMP No. 31156, 1 distal half of a pectoral spine.

The spine is that of a small individual, probably about 45 or 50 mm. in standard length. The fragment is 5 mm. long. Comparison with Recent specimens of appropriate size from the University of Michigan Museum of Zoology (UMMZ) fish collection reveals that this is *I. punctatus* (Rafinesque) and not *Ictalurus furcatus* (LeSueur). The channel catfish is found in lakes and rivers from northeastern México (Rio Pánuco basin) north to the northern end of Lake Huron, and from Cumberland Lake in Saskatchewan east to the St. Lawrence drainage of Quebec.

##### *Ictalurus melas* (Rafinesque)<sup>1</sup>

(Fig. 4 A - C, E)

Referred material: UMMP Nos. 31167-68, 260 pectoral spines (lengths of complete spines range from 7 to 19.6 mm.); UMMP No. 31169, 22 dorsal spines (lengths of complete spines 5.5-20 mm.); UMMP No. 31181 (part), 6 hypohyals; UMMP No. 31181 (part), 20 epiphyals; UMMP No. 31181 (part), 20 ceratohyals; UMMP No. 31183, 11 urohyals; UMMP

<sup>1</sup> In rejecting the name *Ameiurus* for the genus of the bullheads I am following William Ralph Taylor (in press).

No. 31180, 6 parasphenoid fragments; UMMP No. 31182, 6 post-temporals; UMMP No. 31178, 16 frontals; UMMP No. 31170, 1 dermethmoid; UMMP No. 31179, 18 opercula; UMMP No. 31176, 16 hyomandibulars; UMMP Nos. 31163-66, 8 supraoccipitals; UMMP No. 31171, 8 premaxillaries; UMMP No. 31172, 40 dentaries; UMMP No. 31173, 29 articulars; UMMP No. 31174, 14 quadrates; UMMP No. 31175, 133 cleithra; UMMP No. 31177 (part), 12 basi-occipitals; UMMP No. 31177 (part), 18 fragments of Weberian apparatus; UMMP No. 31157, numerous miscellaneous fragments.

The black bullhead is the most common species in the Berends fauna. Its Recent distribution is from the Lake Ontario drainage of western New York and southern Ontario west to Wyoming and southward to Texas and the Gulf coast. It is the most common bullhead of the plains region and is found in ponds and streams.

#### CENTRARCHIDAE

##### *Lepomis* cf. *cyaneus* Rafinesque

(Fig. 5 A - C, F, G)

Referred material: UMMP No. 31144, 4 parasphenoids; UMMP No. 31141, 12 dentary fragments; UMMP No. 31137-38, 4 articulars; UMMP No. 31143, 1 cleithrum; UMMP Nos. 31135-36, 14 maxillaries; UMMP No. 31142, 9 premaxillaries; UMMP Nos. 31139-40, 11 lower pharyngeal bones.

The green sunfish, like the black bullhead, still occurs in the Oklahoma panhandle. This species is characteristic of slow-moving parts of creeks and lakes and is found from Wyoming and South Dakota through Minnesota, Wisconsin, and rarely in the Upper Peninsula of Michigan, through southern Ontario to western New York. It ranges south to southern Alabama, northeastern México, and New Mexico.

#### PERCIDAE

##### *Perca flavescens* (Mitchill)

(Fig. 6 B - D)

Referred material: UMMP No. 30721, 1 hyomandibular; UMMP No. 31130, 4 basi-occipitals; UMMP Nos. 29008, 30722-24, 79 preopercles; UMMP No. 31133, 1 parasphenoid; UMMP No. 31132, 7 posttemporals; UMMP

No. 31131, 4 vomers; UMMP No. 31119, 5 articulars; UMMP No. 31125, 6 quadrates; UMMP No. 31128, 10 premaxillaries; UMMP No. 31126, 24 ceratohyals; UMMP No. 31127, 6 maxillaries; UMMP No. 31124, 1 superior pharyngeal; UMMP No. 31120, 15 dentaries; UMMP No. 31123, 29 cleithra; UMMP No. 31121, 4 subopercles; UMMP No. 31122, 1 interopercle; UMMP No. 31134, 35 opercles; UMMP No. 31129, 20 supracleithra.

The single hyomandibular differs in several respects from the hyomandibular of Recent material of *Perca flavescens* (Fig. 6A). The lateral vertical keel is much higher than that of any of the more than forty specimens that have been examined. Moreover, this keel crosses the vertical axis of the hyomandibular at a more obtuse angle in the fossil and it leans forward in this specimen but is nearly vertical in the Recent perch. However, since these distinctions in the hyomandibular are not supported by differences in the other bones now available, it seems likely that the specimen at hand is abnormal.

*Perca flavescens* today ranges from Lesser Slave Lake of the Mackenzie basin and the Hudson Bay drainage of west-central and eastern Canada, south to the northern parts of Missouri, Illinois, Indiana, Ohio, and western Pennsylvania. It is found on the Atlantic slope from New Brunswick to South Carolina. The yellow perch inhabits lakes and slower parts of streams.

#### SCIAENIDAE

##### *Aplodinotus grunniens* Rafinesque

(Fig. 5 D - E)

Referred material: UMMP Nos. 31153-54, 3 inferior pharyngeal bones.

Two of the specimens are nearly perfect and the other is quite fragmentary. The two complete specimens measure 4.0 mm. by 3.9 mm. and 3.9 mm. by 3.8 mm. in major dimensions. All three are from small individuals about 70 or 80 mm. in standard length.

The Recent distribution of the freshwater drum is from the basin of the Río Usumacinta, along the boundary of México and Guatemala, to Lake Winnipeg and Lake Abitibi in Canada. The species usually inhabits lakes and larger rivers.

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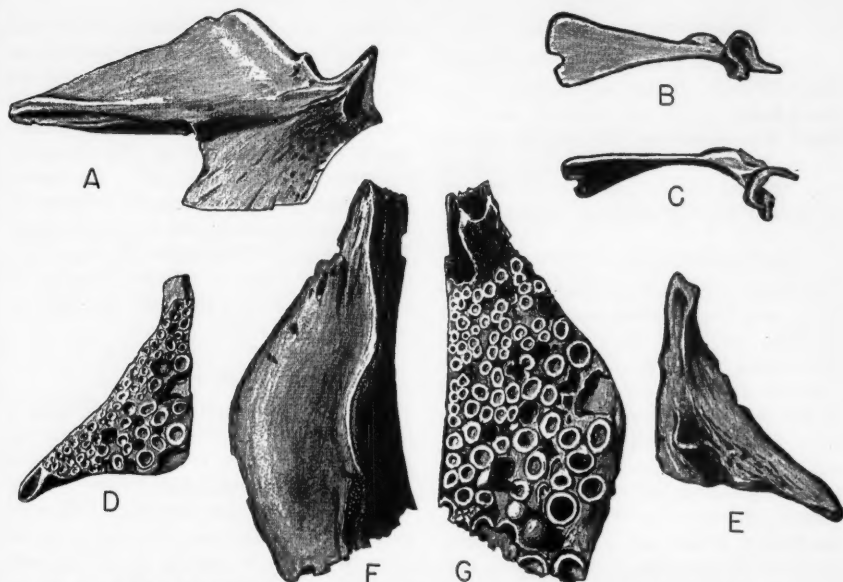


Fig. 5. Skeletal remains of *Lepomis* and *Aplodinotus*. A, Lateral view of left articular of *Lepomis* cf. *cyanellus* (UMMP No. 31137). B, Medial view of left maxillary of *Lepomis* cf. *cyanellus* (UMMP No. 31136). C, Dorsal view of same. D, Dorsal view of left lower pharyngeal of *Aplodinotus grunniens* (UMMP No. 31154). E, Ventral view of same. F, Ventral view of lower pharyngeal of *Lepomis* cf. *cyanellus* (UMMP No. 31139). G, Dorsal view of same.

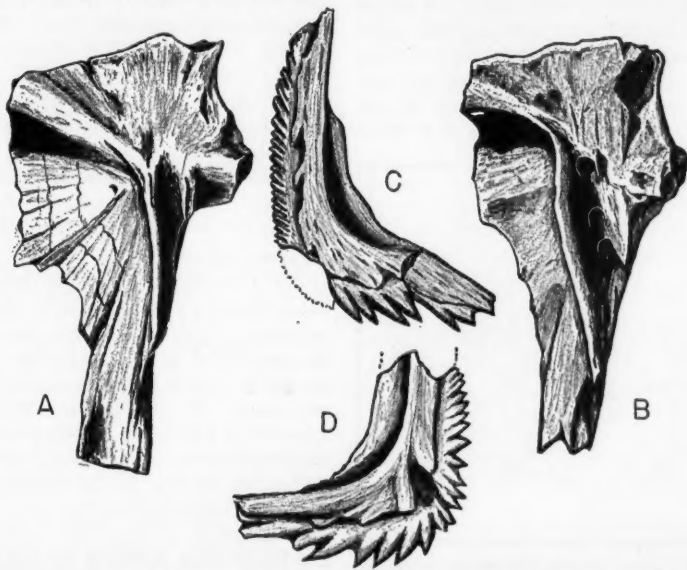


Fig. 6. Bones of *Perca flavescens*. A, Lateral view of left hyomandibular of Recent specimen (UMMZ No. 126220). B, Lateral view of left hyomandibular of fossil (UMMP No. 30721). C, Lateral view of right preopercle of fossil (UMMP No. 30724). D, Lateral view of fragment of left preopercle of fossil (UMMP No. 30722).

## ASSOCIATED VERTEBRATES

In addition to the species previously listed from the fauna (Rinker and Hibbard, 1952), the following species of mammals were collected in the summer of 1953: *Sorex* cf. *cinereus* Kerr; *Blarina* cf. *brevicauda* (Say); *Geomys* sp.; *Ondatra* sp.; *Microtus pennsylvanicus* (Ord); and *Microtus ochrogaster* (Wagner).

## SIGNIFICANCE OF THE BERENDS FAUNA

Of the ten identifiable species in the Berends fauna, only two, *Ictalurus melas* and *Lepomis cyanellus*, are found in that region today. *Notemigonus crysoleucas* and *Aplodinotus grunniens* are widespread and range from the Gulf of Mexico, and Guatemala, respectively, north some distance into Canada. *Lepisosteus* sp. and *Ictalurus punctatus* are not found north of Lake Huron, southern Manitoba, or southern Ontario, although they are common south to the Gulf of Mexico and in northern México. *Semotilus atromaculatus* and *Calostomus commersoni* are most abundant in the northern part of North America, but they are found some distance south of the Oklahoma panhandle. Their absence from the immediate vicinity of the Berends fauna is explained by the lack of suitable spawning areas, although such gravel beds were available to them during glacial times. *Perca flavescens* is the species that most closely restricts the southern limit of the fauna, for it is not found south of northern

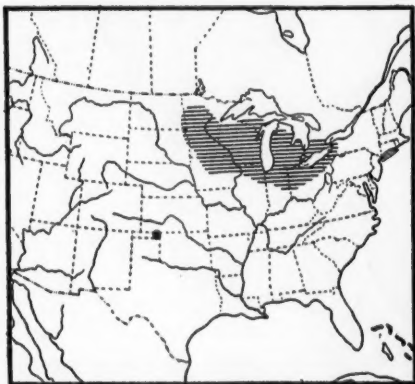


Fig. 7. Map showing the region where all species found in the Berends fauna now occur together (shaded area). The black dot in the Oklahoma panhandle indicates the locality of the Berends fauna.

Missouri, Illinois, Iowa, northern Ohio and western Pennsylvania. *Esox masquinongy* occurs in the Tennessee River basin but west of the Mississippi it has not been reported south of central Iowa. Figure 7 shows where all of these species occur together today. The climate of the central high plains was cool at the time of the Berends fauna and this is also indicated by the associated mollusks and by the mammals. Mrs. Kathryn H. Clisby reports finding spruce, fir, and pine pollen in samples taken in the summer of 1953 from the same deposits from which the fossils came.

## SUMMARY

The Berends Pleistocene fauna of Beaver County, Oklahoma, contains abundant remains of vertebrates and mollusks. Twelve fishes have been identified and by superimposing the ranges of all of them we find that the comparable present-day fauna inhabits the region from Minnesota to western New York and from the north shore of Lake Huron to central Iowa, central Indiana, and northern Ohio. The conclusion that the climate of the Great Plains was cooler and more moist when this fauna existed is borne out by other groups. The molluscan and mammalian fossils consist also of forms whose descendents or close relatives live in a cooler and moister climate than exists in that region today. Pine, fir, and spruce pollen have been found in the deposits from which the fish remains came and this supports the zoological evidence of climatic change.

## ACKNOWLEDGMENTS

I am greatly indebted to Claude W. Hibbard of the University of Michigan Museum of Paleontology for the privilege of studying these specimens, for advice and encouragement in the preparation of the manuscript, and for permission to publish the new records of mammal remains (identified by him). My sincerest appreciation goes to the following members of the 1953 Museum of Paleontology field party: William G. Melton Jr., Michael O. Woodburne, H. George Golden, Eugene Bowser, and Faye Granfield Hibbard. Reeve M. Bailey and Robert Rush Miller, of the University of Michigan Museum of Zoology, critically read the manuscript and made many helpful suggestions. Coy and Charles Berends of Gate,

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Oklahoma, generously gave permission to excavate the deposits on their land. Mrs. Kathryn H. Clisby, Research Associate of the Department of Geology and Geography of Oberlin College, supplied the pollen-analysis data.

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MICHIGAN.

## Ichthyological Notes

DISTRIBUTION OF THE AMERICAN CYPRINID FISH *HYBOGNATHUS HANKINSONI* WITH COMMENTS ON ITS ORIGINAL DESCRIPTION.—During recent years I have received repeated requests for the citation to the original description of *Hybognathus hankinsoni*. Confusion as to the location stems from the appearance of that diagnosis in the work of a writer (Jordan) other than its true author (Hubbs), and a failure to specify that the treatment is, in fact, the proposal of a new species. In this attempt to clarify the situation a lectotype for the species is also designated and briefly described, and the distribution of *H. hankinsoni* is mapped and discussed.

The first reference to the species under the present name (Hubbs and Greene, 1928, *Mich. Acad. Sci., Arts and Letters*, 8 (1927): 382, 389) reads as follows: "A revision of the species of *Hybognathus* made by the senior writer, presently to be reported upon [this revision has not yet appeared], has disclosed the fact that the form occupying most of the Great Lakes drainage basin is an undescribed species. This will be described as *Hybognathus hankinsoni* Hubbs." This is an obvious *nomen nudum*. At about this time Carl L. Hubbs assisted David Starr Jordan in the revision of the fish section of his final Manual of the Vertebrate Animals of the Northeastern United States (1929, World Book Co., New York, 13th ed., pp. xxxi + 446). On page 88 there appears the following:

*Hybognathus hankinsoni* Hubbs. Head blunter color; [sic] darker; fins more rounded than in *nuchalis*, and scales with many weak, instead of a few strong, radii. S. Ont. and Great Lakes region, W. to N. Dak., Colo., and Mo. (Diagnosis by Hubbs.) (To T. L. Hankinson.)

Though brief, this diagnosis is adequate to identify the species subsequently known by this name. Since it is evident that Hubbs was responsible for the name and its diagnosis, the brassy minnow is properly attributed to Hubbs, in Jordan (*op. cit.*). *H. hankinsoni* has been figured and described or compared with related species by Simon (1946, Wyoming Game and Fish Dept., Bull. 4: 87-8), Hubbs and Lagler (1947, Cranbrook Inst. Sci., Bull. 26: 59), Eddy and Surber (1947, Northern Fishes: 125, 146-7), Dymond (1947, Royal Ont. Mus. Zool., Misc. Publ. 1: 18, 22), Bailey (1951, Iowa Fish and Fishing, by J. R. Harlan and E. B. Speaker: 217), Beckman (1952, Univ. Colo. Mus., Leaflet 11: 60), and Carl and Clemens (1953, Brit. Col. Prov. Mus., Handbook 5 (2nd. ed.): 77).

Many specimens in the Museum of Zoology of the University of Michigan were catalogued as paratypes of *Hybognathus hankinsoni* prior to the original description, but none was designated as the holotype. With the concurrence of Dr. Hubbs, we now specify UMMZ No. 84266, one of the original syntypes, as lectotype of *H. hankinsoni* Hubbs. This specimen, an adult 64.5 mm. in standard length, was collected in Dead River, Sec. 8, T.48N., R.26W., in the Lake Superior watershed, Marquette County, Michigan, on July 20, 1927, by C. A. Montague.

The lectotype has a complete lateral line with 37 scales; body-circumference scales 11 + 2 + 14 (below lateral lines) = 27; caudal-peduncle scales 6 + 2 + 5 = 13; fin rays—dorsal 8, anal 8, pectoral 13-14, pelvic 8-8, caudal 19. The following measurements are expressed as percentages of the standard



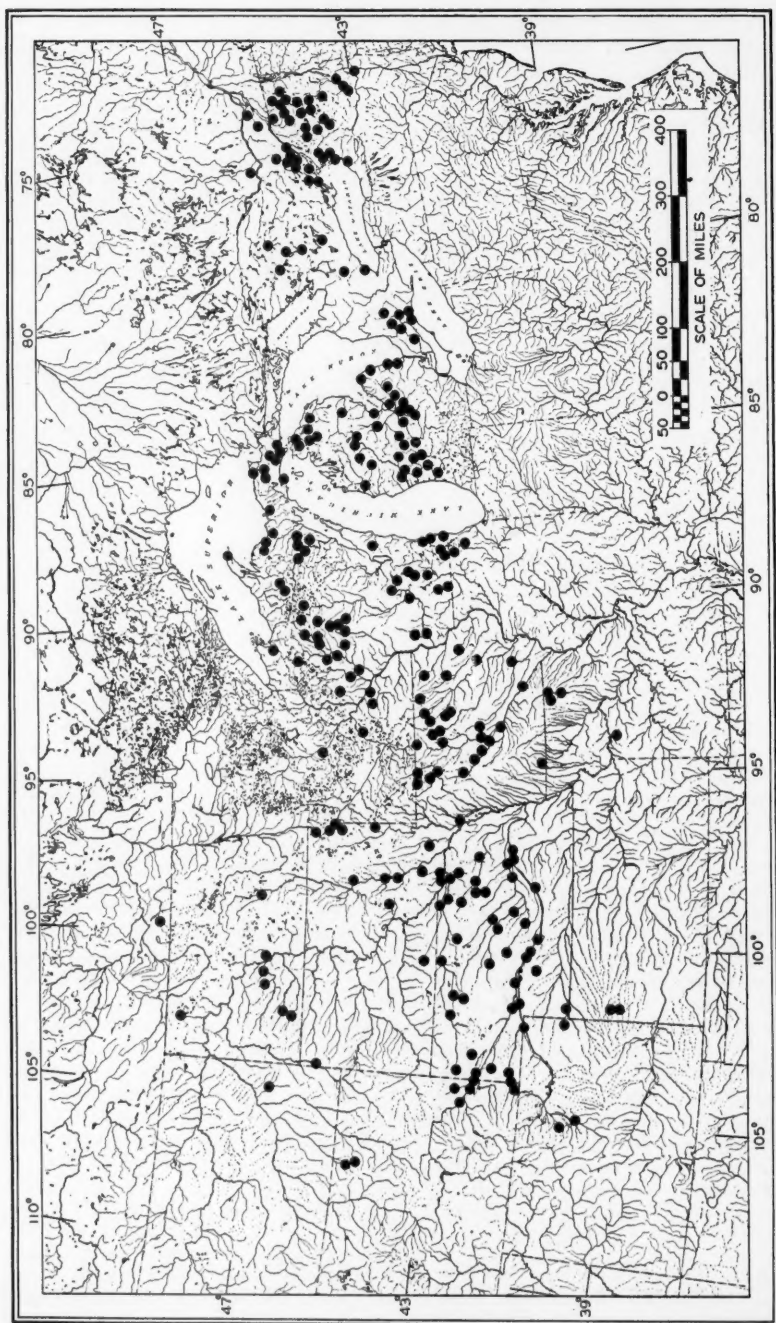


Fig. 1. Northern United States and Southern Canada showing the natural distribution of *Hybogadus hankinsoni* Hubbs by record stations. The species has been successfully introduced into British Columbia (see text).

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length: head length 26.7, head width 14.7, snout length 8.2, orbit length 6.2, predorsal length 49.9, dorsal fin height 22.5, pectoral fin length 21.7. Head bluntly rounded, orbit moderate (4.3 in head), dorsal fin rounded, lateral scales with about 17 to 19 weak radii and with the circuli gently curved at anterobasal corners.

The type locality of *Hybognathus hankinsoni* is remote from the ranges of other species in the genus, for none of which are there verified records above Niagara Falls in the Great Lakes system. The brassy minnow is occasionally taken with *Hybognathus nuchalis* in the Mississippi basin, and occurs in the same area with *H. nuchalis* *regia*<sup>1</sup> in parts of the Lake Ontario drainage and in the upper Hudson River system, where at one station the two were collected together. For the most part, however, ecological differences keep the species apart even where they are sympatric. *H. hankinsoni* typically inhabits creeks or small rivers, whereas *H. nuchalis* (including *H. placita*, *avet.*) abounds in moderate to large rivers, backwaters, and bayous, ascending creeks infrequently except on the Great Plains. In the eastern part of its range *hankinsoni* is commonly found in the stained waters of bog streams and lakes.

The distribution of *Hybognathus hankinsoni* (Fig. 1) has a wide longitudinal extent but is narrow latitudinally, especially in the east. In much of the Missouri River system the brassy minnow is common and widespread, as revealed, for example, by the thorough survey of Nebraska by Raymond E. Johnson. In Missouri, the equally intensive explorations by George V. Harry indicate only one residual area of recent occurrence—near the Iowa line in the Chariton River system. An old collection in the United States National Museum (No. 35756) from Lafayette County, Missouri, suggests a somewhat more extensive distribution in this region in years past, but the data are possibly in error. *H. hankinsoni* is the only species of *Hybognathus* known in the Red River drainage, whence specimens have been examined from Lake Traverse, South Dakota, and the Little Pembina River, Manitoba (Royal Ontario Museum of Zoology and Paleontology, No. 14839). In view of the present

distribution, it seems obvious that *H. hankinsoni* survived the Wisconsin glaciation in the Missouri and Upper Mississippi drainages. Following the retreat of the ice front, the species made its way into the Red River drainage via the Lake Agassiz glacial outlet, and into the Great Lakes area through the St. Croix and the Fox river connectives, as indicated by Greene (1935, The Distribution of Wisconsin Fishes. Madison: pp. 14-6, 121). Since the brassy minnow does not persist anywhere in the Ohio River drainage and is found in the Illinois system only near its source, where it probably arrived through recent secondary connections, use by the species of the Chicago outlet seems questionable and passage up the Maumee-Wabash outlet most unlikely. After gaining access to the Great Lakes, *H. hankinsoni* apparently spread rapidly to the east from Wisconsin across Michigan and southern Ontario, traversing either the Trent outlet from Glacial Lake Algonquin or the Nipissing-Ottawa channel from the Nipissing Great Lakes, or both, and then by way of the St. Lawrence River and Lake Champlain reached the eastern terminus of its modern distribution in the Upper Hudson River drainage. Like Radforth (1944, Contr. Royal Ont. Mus. Zool., 25: 88-9), I believe *Hybognathus hankinsoni* is of Mississippi derivation and did not reinvade the eastern part of its range from the Susquehanna River system (where it does not now occur), as postulated by Greene (*op. cit.*: 121).

Recently *Hybognathus hankinsoni* has become established, clearly as the result of introduction, in the lower Fraser River system in British Columbia (1953, Carl and Clemens, *op. cit.*). Specimens from the Stave River, New Westminster County, are in the Museum of Zoology.

Several colleagues have helped materially in the preparation of this note and to them I express my sincere thanks: Dr. Carl L. Hubbs identified many lots of *H. hankinsoni* in the Museum of Zoology; Dr. Ernest A. Lachner loaned specimens in the United States National Museum; Mr. Vianney Legendre loaned a specimen from Quebec; Dr. Edward C. Raney and Mr. C. Richard Robins furnished New York and Illinois records from the Cornell University collection; and Dr. W. B. Scott granted access to the many Canadian specimens in the Royal Ontario Museum of Zoology and Paleontology and assisted in plotting several collection records. The Wisconsin records on Fig. 1 are taken directly from Dr. C. Willard Greene's distributional study (*op. cit.*). Many of the Iowa stations are based on specimens in the Iowa State College collection. The bulk of the locality records not otherwise indicated are in the Museum of Zoology.—REEVE M. BAILEY, Museum of Zoology, University of Michigan, Ann Arbor, Michigan.

<sup>1</sup> The eastern silvery minnow was ranked as a subspecies of *Hybognathus nuchalis* by Hubbs and Lagler (1941, Cranbrook Inst. Sci., Bull. 18: 60), who commented: "... apparently intergrading along the Gulf states with *H. n. nuchalis*." *H. n. regia* ranges south on the Atlantic slope to the Altamaha River system, Georgia; *H. n. nuchalis* occurs eastward in the Gulf states to the Alabama River in Alabama but is not known from Georgia or Florida. Neither subspecies lives in upland streams of the Appalachian Mountains, and no *Hybognathus* is known from the Apalachicola River basin. Since the ranges of *regia* and *nuchalis* are well separated, gene interchange under natural conditions is impossible. However, the characters advanced to distinguish the races (Hubbs and Lagler, *op. cit.*, p. 50) have not been adequately quantified or they overlap broadly. Until these forms have been accorded thorough study, it is perhaps best provisionally to continue to treat them as subspecies.

**NORTHERLY OCCURRENCES OF WARM-WATER FISHES IN THE WESTERN ATLANTIC.**—In the summer and fall of 1953, I was able to record several northerly occurrences of warm-water fishes of the families Scombridae, Carangidae and Coryphaenidae. These include some individuals taken from research vessels of the Woods Hole Oceanographic Institution in offshore waters, and others caught in Mr. Norman Benson's trap at Quissett, Massachusetts, in Buzzards Bay.

Some of the captures appear to constitute new northern records. Others are of species which have previously been listed from these latitudes but whose occurrences there are not often described in the literature. Abundance or scarcity of the respective species was checked in Bigelow and Schroeder (1953, Fish. Bull. U.S.F.W.S., 53 (74): 1-577) for the Gulf of Maine, and in Nichols and Breder (1934, Zoologica, 9 (1): 1-192) for New York and southern New England, and other regional works, as well as COPEIA and the Zoological Record.

*Neothunnus albacares* (Bonnaterre).—Two yellow-fin tuna, each 117 cm. long, were taken by trolling from the ATLANTIS in waters southeast of New York. One was caught on October 24 about 100 miles from that port, where the Hudson Canyon crosses the 100-fathom curve (39°22'N, 72°22'W), and the other was taken on November 11 about 110 miles further to the southeastward (38°18'N, 70°29'W), about 183 miles south of Martha's Vineyard. Catches of this species in northern waters by sport fishermen have been reported occasionally in the nonscientific press, but in such cases the identification is often open to question. The species is not recorded in scientific literature from the Gulf of Maine, or from New York and southern New England. Nichols and LaMonte (1941, Ichthyol. Contrib. Internat. Game Fish Assoc., 1 (3): 30) listed a specimen (as *Neothunnus albacora*) taken off Ocean City, Maryland, (38°23'N). These captures, therefore, occurred at or near the probable northern limit of the range of the species, although some individuals may have been taken off northern New Jersey or Long Island.

*Scomberomorus cavalla* (Cuvier).—Thirteen king mackerel averaging 70 cm. in length were taken in the trap at Quissett between September 28 and October 9. This species was not known from the Gulf of Maine until as recently as August, 1949, when one was taken at North Truro, Cape Cod. This is the most northerly record of its occurrence. It was listed as formerly abundant, now rare, off New York and southern New England.

*Seriola falcata* Cuvier and Valenciennes.—A falcate amberjack 34 cm. long was taken from a school of about a dozen individuals of similar size which approached the ATLANTIS when she was hove to on November 1 (39°09'N, 62°05'W), about

610 miles east of Cape May. While it is not unusual to find juvenile carangids drifting with weeds in the offshore waters, the larger individuals are seldom recorded so far from land. Two specimens, 8 and 27 cm. long, respectively, were taken near the surface along with two *Caranx ruber* and over 200 *C. crysos* in a 2-meter ring net from the BEAR on September 10 (39°13'N, 71°13'W), about 145 miles east of Atlantic City. As I have found no mention of the occurrence of this species north of Bermuda and Cape Hatteras, these captures appear to constitute a new northern record.

*Caranx crysos* (Mitchill).—Ten blue runners averaging 40 cm. in length were taken close to the surface with hook and line from the CAPT. BILL II on July 29 (40°04'N, 70°34'W), 77 miles south of Martha's Vineyard. The offshore capture of large blue runners is unusual, as the adults of this species are regarded as inshore fishes. About 40 individuals from 6 to 15 cm. long were caught at the surface by net from the BEAR on August 26 (39°29'N, 70°40'W), 112 miles south of Martha's Vineyard. Over 200 *crysos* of this same size range were taken from this vessel in the same general area on September 10, along with the two *C. ruber* and two *Seriola falcata*, as mentioned above. The capture of so many small individuals in the offshore waters is interesting in view of the nursery area for the species defined by Nichols (1939, Bull. Bingham Oceanogr. Coll., 7 (2): 1-9) as extending from 37°12' to 32°59'N and from 67°39' to 69°46'W in late August. This area is not far south and east of the locations where so many juveniles were taken from the BEAR. A small school of blue runners about 18 cm. long was seen at the Woods Hole docks, and at least two were taken on hook and line on September 29. Two others of about the same size were caught in the Quissett trap on October 2, and Mr. Benson reported that he had taken about half a bushel of about this length on September 23. In the past few years, *crysos* has been by far the most abundant *Caranx* in sizes large enough to be caught in traps or by hook and line in the Cape Cod area. I have seen many of them from 16 to 20 cm. long taken in Cape Cod Bay as well as on the south side of the Cape, while I have seen only one specimen of *C. hippos* in the same period. The latter has been listed as the most common jack in southern New England, but Mr. Nichols has told me that this referred mainly to very small individuals. The range of *C. crysos* extends northward to Nova Scotia.

*Caranx hippos* (Linnaeus).—An 18-cm. jack crevalle was taken in the Quissett trap on October 9. The species has been recorded from Lynn and Provincetown in the Gulf of Maine, and as far north as Nova Scotia. It was listed as common at Woods Hole. As mentioned above, however, in recent years I have found *C. crysos* in much greater

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numbers than *C. hippos* in the vicinity of Cape Cod.

*Caranx ruber* (Bloch).—Two bar jacks 9 cm. long were taken in a net from the BEAR on September 10 (39°13'N, 71°13'W), along with over 200 *C. crysos* and two *Seriola falcata*. As the most northerly records I have found for *C. ruber* are 38°07'N, 68°45'W to 37°12'N, 67°39'W, from Nichols (*loc. cit.*), this capture appears to represent a northerly extension of its known range.

*Selar crumenophthalmus* (Bloch).—Twenty-eight goggleeye scad all about 16 cm. long were taken in the trap at Quissett from September 26 through October 9. The species has been listed three times from Cape Cod localities in the Gulf of Maine, and as far north as Cape Breton, Nova Scotia. It has been considered common in the fall at Woods Hole.

*Alethis crinitus* (Mitchill).—An 11-cm. thread-fish was taken in the trap at Quissett on September 26. There are two records of the species from the Cape Cod area in the Gulf of Maine and it is listed as rare in New York and southern New England.

*Coryphaena equisetis* Linnaeus.—I have found only one previous record of the little dolphin from off the Atlantic coast<sup>1</sup> of the United States. This was listed by Linton (1905, Bull. U. S. Bur. Fish., 24 (1904): 373) from Cape Lookout, North Carolina (34°35'N). I was fortunate in obtaining a second such record while sport fishing off Cape Hatteras, North Carolina, on October 14, 1952. A 39-cm. specimen was taken from a large school of *C. hippurus* of about the same size. On October 16, 1953, a 40-cm. *equisetis* was taken from the ATLANTIS (38°22'N, 69°35'W), 135 miles south of Nantucket Light Vessel. This appears to be the most northerly capture of the species on record for the western Atlantic, although its close relative, *C. hippurus*, is sometimes abundant off southern New England and has been recorded from the Gulf of Maine and the outer coast of Nova Scotia.

I am indebted to Mr. W. C. Schroeder, Dr. Richard H. Backus, Dr. John Kanwisher, and others of the scientific staff of the Woods Hole Oceanographic Institution, to Captain W. Scott Bray and Boatswain Carl Speight of the ATLANTIS and other members of the personnel of the respective vessels, and to Mr. Norman Benson, for collecting these specimens, and to Mr. Schroeder and Mr. John T. Nichols, of the American Museum of Natural History, for their assistance in preparing this note.—FRANK J. MATHER III, Woods Hole Oceanographic Institution, Woods Hole, Massachusetts. (Contribution No. 702).

<sup>1</sup> In the Straits of Florida, however, the species appears to be fairly common. Al Pflueger, the well-known Miami taxidermist, has told me that these fish are frequently taken in the Gulf Stream off that port, where they are known as "pompano dolphins." He showed me a specimen at his shop, and has presented others to the Department of Zoology at Miami University.

AN AMERICAN RECORD FOR THE BERYCROID FISH *GEPHYROBERYX DARWINI*.—*Gephyroberyx darwini* (Johnson), belonging to the uncommon and little-known family Trachichthyidae, is described as a bathypelagic fish found in the Atlantic, Indian, and Pacific oceans. Johnson (1866, Proc. Zool. Soc. London, 1866: 311-15) described the species from a single specimen taken near Madeira. Goode and Bean (1895, Oceanic Ichthyology, p. 188) and Jordan (1905, Guide to the Study of Fishes, 2: 252) indicated that it is found in Japanese waters. Fowler (1935, Proc. Phila. Acad. Nat. Sci., 87: 374) and Smith (1950, The Sea Fishes of Southern Africa: 152) recorded it from South Africa.

A single individual was taken during the night of April 7-8, 1953, by the otter trawler, MAYFLOWER, 70 miles ESE of Atlantic City, New Jersey (38°40'N Lat., 73°53'W Long.) at a depth of 110 fathoms. This is the first time this species has been recorded from the Western Atlantic, so far as I have been able to determine.

The following meristic characters were obtained: D. VIII, 13; A. III, 11; P. 14 left, 12 right (right fin malformed); V. I, 6. Lateral-line scales 27 left, 26 right; ventral scales 12; 6 spinous rays on dorsal and ventral edges of caudal-fin base; branchiostegals 8; gillrakers 5 + 14 left, 5 + 13 right. The standard length is 350 mm. The following measurements are given as percentages of the standard length: depth, 50.5; head (to end of opercular spine), 36.3; snout, 10.0; eye, 7.1; orbit, 8.3; interorbital, 11.7; postorbital, 19.2; upper jaw, 22.0; pectoral fin, left 22.2, right, 21.7.

Johnson (1866) indicated that "the maxillary reaches backward to the vertical from the middle of the eye." This is true of the present specimen if the vertical is dropped to the lower corner of the maxillary. The tongue of this specimen is not black nor is it adherent; its edges are free. The fourth dorsal spine (which is the longest in Johnson's description) has its tip bent over.

The fish had been out of water about one week when it was received and by that time its red color had begun to fade and the ends of its fins had begun to break off. It is now housed at the United States National Museum, USNM No. 163445.

Thanks are due John Reintjes, U. S. Fish and Wildlife Service, for making the specimen available.—FRANKLIN C. DAIBER, University of Delaware, Newark, Delaware.

HERMAPHRODITISM IN THE ROSYFACE SHINER, *NOTROPIS RUBELLUS*.—Hermaphroditism, the return to the primitive condition of both sexes within one body, is a rare event in natural populations of vertebrates. This condition has been observed in fishes by various authors: Bishop in

COPEIA, No. 80, 1920, pp. 20-1; Chidester in Anat. Rec., 12, 1917, pp. 389-96; Crawford in COPEIA, No. 163, 1927, p. 34; D'Ancona in Pubbl. Staz. Zool. Napoli, 18: 1941, pp. 313-36; Fowler in Science, 36, 1912, pp. 18-9; Howes in Jour. Linn. Soc., 1891, pp. 539-58; James in Jour. Morph., 79 (1): 1946, pp. 93-5; Johnson in COPEIA, 1932 (1), pp. 21-5; Lavenda in COPEIA, 1949 (3), pp. 185-94; Schultz in COPEIA, 1931 (2), p. 64; and Williamson in 24th. Ann. Rept., part 3, of the Fishery Board for Scotland, 1906, pp. 290-2. In these references the hermaphroditic condition was described as either one male and one female gonad, two gonads each possessing male and female characteristics, or paired male and female gonads. It can now be reported that *Notropis rubellus* (Agassiz) also exhibits hermaphroditism under natural conditions.

On August 19, 1953, while seining a riffle typical of the West Branch of French Creek at Wattsburg, Pennsylvania, I captured an adult, two-year-old rosyface shiner with both male and female gonads. This condition was discovered later while sexing over 3,000 adults of this species sampled during the summer in streams comprising the Ohio drainage of northwestern Pennsylvania. Two additional hermaphroditic rosyface shiners were captured from Slippery Rock Creek on February 20, 1954. The age of these two-year-old specimens was also determined by the scale-reading method.

The distinctiveness of these specimens lies in the unusual paired condition of the gonads. A pair of male gonads occurred on the left side of the small intestine and a pair of female gonads was found on the right side. The male gonads were milky white rod-shaped organs of normal size and shape for that age class. The flat, spongy female gonads were also of typical size and shape. The oviduct and vas deferens had distinct openings into the cloaca in all three specimens.

Histological sections were prepared from the earlier specimen. The gonads were imbedded in wax, sectioned, and stained with Ehrlich's Acid Alum Hematoxylin. Microscopic examination of these sections indicated that these particular gonads could not produce functional gametes. Date of collection of this specimen (August 19) was not during the normal breeding season in this region.

Gametes were present in the gonads of the two hermaphroditic specimens obtained in February. Maturing eggs were observed in their ovaries while the testes contained maturing sperm. Normal members of the *N. rubellus* population sampled in February also had gametes in the early stages of maturation.

The following data were recorded from these specimens: Specimen A (August 19th.)—weight,

1.94 grams; standard length, 54.4 mm.; predorsal length, 30.0 mm.; gonad lengths, (male) 10 and 11 mm. and (female) 11 and 12 mm. Specimen B (February 20th.)—weight, 2.85 grams; standard length, 53.6 mm.; predorsal length, 33.6 mm.; gonad lengths, (male) 15 and 16 mm. and (female) 19 and 20 mm. Specimen C (February 20th.)—weight, 2.78 grams; standard length, 58.7 mm.; predorsal length, 33.1 mm.; gonad lengths, (male) 15 and 16 mm. and (female) 18 and 19 mm. All three specimens had the following counts in common: pectoral rays, 12; anal rays, 9; pelvic rays, 8; and dorsal rays, 9.

These unusual specimens show no apparent divergence from other individuals in this particular year-class.—ROGER J. REED, *Pymatuning Laboratory of Field Biology, University of Pittsburgh, Pittsburgh, 13, Pennsylvania.*

**MORTALITY AMONG BROOK TROUT, *SALVELINUS FONTINALIS*, RESULTING FROM ATTACKS OF FRESHWATER LEECHES.**—During July, 1953, the Maine Department of Inland Fisheries and Game was asked to investigate an unusual mortality among brook trout, *Salvelinus fontinalis* (Mitchill), at Quimby Pond, Rangeley Township, Franklin County, Maine. Quimby Pond is a shallow, homothermous pond of approximately 150 acres in which summer water temperatures occasionally become critically high. Brook trout provide a good sport fishery in this pond mainly because of the absence of serious competition from other fishes and because of the existence of numerous underwater springs. Numbers of trout may be seen congregated in the spring holes during short periods when water temperatures are above 72° to 74° F.

One of the largest springs in the pond is near the northeastern shore, in approximately two feet of water. The shallowness of the water and the nearness to shore encourage poaching and bird predation when trout are congregated here. Sportsmen state that the yearly loss to these sources has been high. Control of this loss has been attempted in recent years by placing brush in the spring to provide shelter. While the brush shelter has been quite effective in reducing bird predation and poaching, it has also had an effect that was unforeseen; it has apparently created an ideal habitat for *Macrobdella decora* (Say) and *Haemopsis grandis* (Verrill), leeches numerous in many small ponds throughout the area. During the summer of 1953, these leeches (and possibly other species also) were very abundant in and around the brush shelter.

On July 24, 1953, fifty to sixty large trout were congregated in the spring hole and were being fiercely attacked by hordes of *M. decora* and *H. grandis* from the surrounding brush. These leeches

belong to the same family as the leeches associated with the fish. They are reported from being present in the waters of the Great Lakes region of Canada.

It was found that the leeches were in place in the spring hole and were seen ingesting the trout. The trout tried to escape but were unsuccessful. A few more trout were seen in the spring hole. The fish were congregated in the spring hole.

Three trout were nearly dead. The trout were topkicked. *M. decora* and *H. grandis* showed the following characteristics: possibly the most common fish because of the heart and the body of the leech resulted in quite a lot of blood.

The trout were taken from the spring hole around July 24. The trout were apparently numerous.

It appeared that the American leeches developed the conical teeth and the sucker. The distribution of the leeches was of the type of penetration, the capacity of the leeches to penetrate the skin of the trout.

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belong to the Hirudidae, a family not normally associated with fish. Both species have been reported from the northern region of the United States, being particularly abundant throughout the Great Lakes region, New York, New England, and much of Canada.

It was possible to observe the struggles taking place in the spring hole quite clearly. One *M. decora* was seen to attach itself to the side of a trout weighing approximately two pounds. The fish immediately tried to dislodge the attacker by scraping its side on the bottom and on brush. The leech was successfully dislodged but the trout was attacked again a few minutes later. This procedure was repeated several times and would presumably continue until the fish became exhausted and submitted. The congregated trout showed no inclination to leave the spring hole despite their continual harassment.

Three trout were found dead and a fourth was nearly dead. The dying fish was captured and autopsied. At the time of capture, six leeches (both *M. decora* and *H. grandis*) were attached to the gill arches, isthmus, and fin bases. Small, red wounds showed where leeches had fed and dropped off, or, possibly, where leeches had originally attached and then moved later to more vascular areas as the fish became less active. One *M. decora* was attached under the right pectoral fin in the vicinity of the heart and had apparently rasped an opening through the body wall and into the ventral aorta. The color of the liver was creamy-white. Very little blood resulted from cutting flesh or viscera. It appeared quite certain that the fish was dying from loss of blood.

The three dead trout exhibited identical symptoms and were also infested with leeches. Sportsmen reported finding over 20 dead trout in and around the spring during the three days preceding July 24. All victims were large, ranging in weight from one to two pounds. The larger fish were apparently selected for attack; small trout were also numerous in the spring hole but were unmolested.

It appeared that *M. decora* and *H. grandis* were equally involved in the attacks. *M. decora*, the American medicinal leech, belongs to the monostichodont group and each of the three strongly developed jaws is provided with approximately 65 conical teeth (actual counts were 63 and 65). These teeth constitute a formidable cutting apparatus and *M. decora* is known to be a ferocious blood-sucker. *H. grandis*, on the other hand, belongs to the distichodonts, a group in which jaws are weakly developed. *H. grandis* lacks teeth and is incapable of penetrating intact surfaces. It is obvious, therefore, that this leech was involved in a secondary capacity only, attacking wounds made by *M. decora* or wounds already existent.

An attempt to reduce leech predation, and at the

same time to prevent renewed bird predation and poaching, was made by replacing the brush shelter with a woven-wire screen suspended several inches above the water. Baiting and trapping of leeches were also attempted. Cooler weather followed July 24, however, and the trout moved away from the spring within a few days. It was thus impossible to make further observations or to determine the effectiveness of control.

Attack and destruction of healthy, adult trout by leeches is unusual and is undoubtedly possible only where special conditions bring heavy concentrations of trout and leeches into prolonged contact.—ROBERT S. RUPP, *Maine Department of Inland Fisheries and Game, Augusta, Maine*, and MARVIN C. MEYER, *Department of Zoology, University of Maine, Orono, Maine*.

NOTES ON THE GREAT WHITE SHARK, *CARCHARODON CARCHARIAS*, IN CANADIAN ATLANTIC WATERS.—While definite records of the great white shark in Canadian Atlantic waters are few (Piers, 1934, *Proc. Nova Scotia Inst. Sci.*, 18 (3): 192-203; Vladikov and McKenzie, 1935, *Ibid.*, 19 (1): 47; Scattergood, 1951, *COPEIA* (4): 297-8), persistent reports of encounters with sharks apparently of this species suggest that during the last few years it has become a regular summer visitor.

On August 20, 1952, a porpoise hunter, collecting specimens from a skiff for the Atlantic Biological Station in the area between Passamaquoddy Bay and Grand Manan Island, saw a full-grown porpoise, *Phocaena phocaena*, which he was about to shoot, bitten in two by a shark. The shark apparently swallowed the hind portion while the hunter retrieved the head end with a gaff. The shark then circled the skiff closely and was seen to be of a pale grey color dorsally and lighter ventrally. It was a little longer than the 14-foot skiff, which was painted black. The hunter shot the shark in the head with a rifle and it swam away.

On July 9, 1953, a large unidentified fish attacked a 12- to 14-foot moving dory at Fourchu, on the northeastern coast of Cape Breton Island, Nova Scotia, smashing an 8-inch hole in the bottom and drowning one of the two occupants, a Mr. John D. Burns. A fragment of one of the attacker's teeth which had been left imbedded in the wood of the dory was sent to William C. Schroeder, of the Museum of Comparative Zoology and the Woods Hole Oceanographic Institution, who identified it as definitely having come from the great white or man-eater shark, *Carcharodon carcharias* (Linnaeus). He noted further that the tooth was twice as large as, and fitted precisely the end of, the tooth drawn in figure 22B by Bigelow and Schroeder (1948, *Fishes of the Western North Atlantic*, Vol. 1





lege, stated that on September 11, 1941, "Up Estatoe Creek, in northern part of Pickens County, several miles below and perhaps five to six miles southwest of Rocky Bottom, Mr. O. L. Cartwright took a fine specimen of this distinctive species. About 4 to 5" long, tail slender and complete.... It was at full length in one of the slight irregularities of a damp, shady, vertical, lichen-covered cliff (of granite rock) which implies climbing habits." Estatoe Creek lies in the northwestern part of Pickens County.

John A. Quinby and I visited the region near Jocassee, Oconee County, on October 24 and 25, 1953. In the vicinity of Jocassee (elevation about 1000'), nine specimens of *A. aeneus* were taken, all from rocky outcroppings, either natural or exposed by man. Five individuals (ChM 53.169.1) were taken 10.4 mi. by road NNW of Salem on the road to the Upper Whitewater Falls, Oconee County. Here there is a low rocky cliff on the upper side of the road, apparently exposed by road building activities. Virgil G. Sleight of the University of Miami identified a sample of the rock as granite gneiss. Four additional salamanders were seen. All nine of the salamanders were in the cracks and crevices of the much-weathered rock, three being collected when a small section of the outcropping was accidentally dislodged. All were taken in the late morning and were moderately active. One is a juvenile with a snout-vent length of 13 mm.; the others, three males and a female, vary in snout-vent length from 40 to 57 mm. The total length of the largest individual (a male) is 127 mm.

*Aneides aeneus* was also taken at three other localities in the immediate vicinity of Jocassee: 1.8 mi. SE of Jocassee (ChM 53.169.2 (2)); 1.9 mi. NW of Jocassee (ChM 53.169.4 (1)); 2.1 mi. NW of Jocassee (ChM 53.169.5 (1)). The green salamander has been previously reported from Jocassee by Gordon (*loc. cit.*). The latter two localities are typical of the natural rocky outcroppings with which I have found this salamander associated in Kentucky, West Virginia, and Georgia. These outcroppings are in mixed woods, well shaded and cool during the heat of the day; the salamanders were taken from rather superficial breaks in the rock surface.

At the locality 1.8 mi. SE of Jocassee, the salamanders were taken from a man-made vertical cliff on the south side of the Keowee River. The cliff is much exposed and only lightly covered with moss and herbaceous plants. Two females (snout-vent lengths, 56 and 47 mm.) were taken from exposed but shady situations in this cliff in the early afternoon.

The surface of the rock in all places visited is not weathered in pockets, such as those pointed out by Walker and Goodpaster (1941, COPEIA

(3): 178) as suitable habitat for *Aneides aeneus* in limestone areas in southern Ohio. Rather, the habitat resembles that described by Gordon and Smith (1949, COPEIA (3): 173) and Gordon (*op. cit.*: 674-5) as harboring *Aneides* in the vicinity of Highlands, Macon County, North Carolina, a locality at which I have also collected.

Green salamanders were seen but not collected at another locality in Oconee County. In a man-made outcropping, 1.1 mi. (by road) north of the Jocassee Club grounds on Thompson Creek, two *Aneides* were seen in the crevices in the rock face.

Another visit to the northern section of South Carolina was made, in the company of Thomas M. Uzzell, Jr., on November 20-22, 1953. *Aneides aeneus* was secured at two additional localities. Three adult females, two adult males, and two juveniles (ChM 53.179.4) were collected 3.3 mi. N of Rocky Bottom, Pickens County. Both immature individuals measure 13 mm. in snout-vent length. The largest specimen is a male (total length, 133 mm., snout-vent length, 59 mm.). All the salamanders were taken from an exposed high cliff and outcroppings which had been made when the highway was constructed. At least six other green salamanders were seen. From the same outcroppings, but not the same crevices that harbored *Aneides aeneus*, we collected *Plethodon jordani melaventris* and *Desmognathus monticola monticola*. Two other specimens of *Aneides* (ChM 53.179.47) were secured 2.0 mi. S of Caesar's Head community, Caesar's Head Mountain, Greenville County. Both are females (snout-vent lengths, 60 and 43 mm.) and were collected from sheltered crevices in a natural outcropping, immediately adjacent to an intermittent stream and waterfall. The stream was flowing at the time of collection, due to recent rains. In the rubble of the stream and crevices of the wet outcropping beneath the water fall, *Desmognathus ochrophaeus carolinensis* was common.

Of the 24 specimens of *Aneides aeneus* at hand from South Carolina, six are very young individuals, ranging from 22 mm. to 27 mm. in total length, and from 13 mm. to 17 mm. in snout-vent length.

Specimens of the green salamander have now been taken at ten localities and have been observed at another—all in Pickens, Oconee, and Greenville counties. Undoubtedly searching in suitable rocky outcroppings will reveal that *Aneides* is more abundant than supposed in the mountainous southern border region of the Blue Ridge Province in South Carolina.

I wish to thank Thomas M. Uzzell, Jr., and John A. Quinby for assistance in collecting; R. E. Ware for his copying data from the notes kept by the late Franklin Sherman; and William E. Duellman for checking certain literature references at my request. J. C. Nicholls of Murphy, North Carolina,

suggested that *Aneides* would be found in the vicinity of Jocassee, and his suggestion initiated the successful search.—ALBERT SCHWARTZ, *Charleston Museum, Charleston 16, South Carolina.*

THE PAINTED TURTLE, *CHRYSEMYS PICTA PICTA*, IN EASTERN TENNESSEE.—Pope (1946, *Turtles of the United States and Canada*: 182-3) and Carr (1952, *Handbook of Turtles*: 214) do not include Tennessee in the range of *Chrysemys picta picta*. Carr (*op. cit.*: 230) does suggest the possibility of intergradation among *C. p. dorsalis*, *C. p. marginata*, and *C. p. picta* in "... western North Carolina, northern Georgia, and Alabama and eastern Tennessee. ..." King (1939, *Amer. Midl. Nat.*, 21 (3): 579) cited two specimens of *C. p. picta* from Cades Cove, Great Smoky Mountains National Park, Blount County, Tennessee, and attributed them to a relict population. Eight specimens of *C. picta* have been collected in eastern Tennessee by the author and his students. Eastern Tennessee as used in this paper is that part of the state east of the Cumberland Plateau Front (also known as Walden Ridge).

The Tennessee River is the major stream of eastern Tennessee and drains most of this area. Its main tributaries are located as follows: in the northeast the Holston River, receiving drainage from the mountains and Great Valley region of southwestern Virginia and the mountains of western North Carolina; the French Broad and Nolichucky Rivers arising in the mountains of northwestern North Carolina; in the north central part the Clinch and Powell Rivers, each with headwaters in extreme southwestern Virginia; in the east the Little Tennessee and Hiwassee Rivers, each with headwaters in the mountains of eastern Tennessee and western North Carolina and the mountains of extreme northeastern Georgia (the Hiwassee River). The Cumberland Plateau drainage divide is west of the limits of eastern Tennessee as herein delimited.

The following data were obtained from the two specimens in the Great Smoky Mountains National Park collection (CPP) and the eight mentioned above, now in the author's collection (RMJ). All of the specimens possess light foremargins on the central and lateral laminae and a complete (CPP-1, CPP-2, RMJ-214, RMJ-444, RMJ-452-3) or an incomplete (RMJ-214-2, RMJ-452, RMJ-452-2, RMJ-453, RMJ-living) middorsal red stripe extending from the anterior margin of the precentral to or through the postcentral laminae. In specimens CPP-1, RMJ-444, RMJ-452, RMJ-452-2, and RMJ-453 the seam between centrals two and three is aligned with the seams between the second and third lateral laminae. In the remaining specimens the seam between centrals two and three is slightly in advance of the seam between laterals two and

three as follows: CPP-2, 1.9 mm. on left, 5.8 mm. on right; RMJ-214, 2.2 mm. on left, 2.5 mm. on right; RMJ-214-2, 2.7 mm. on left, 2.6 mm. on right; RMJ-452-3, 2.6 mm. on left, 1.7 mm. on right; RMJ-living, 2.1 mm. on left, 2.0 mm. on right. Specimens RMJ-214, RMJ-214-2, and RMJ-452-3 possess a dusky central figure on the plastron half or less the width of the plastron. The carapace lengths (Table I) are within the lengths given for both *C. p. picta* and *C. p. marginata* by Carr (*op. cit.*: 215, 230).

The light foremargins on the laminae of the carapace and the alignment of seams between centrals two and three with lateral laminae two and three and the immaculate yellow plastron are characters of *C. p. picta*. The absence or obsolescence of the light foremargins of the carapace laminae and the staggered condition of the carapace seams and the dark central figure of the plastron are characters of *C. p. marginata*. *C. p. dorsalis* also has the alternation of the seams between the carapace laminae and the red dorsal stripe is usually very broad and conspicuous (Carr, *op. cit.*). Cagle (*in litt.*) states that he finds the dorsal stripe is wider than the stripes of the forelegs in *C. p. dorsalis*. All of the

TABLE I  
DATA OBTAINED FROM 10 SPECIMENS OF *Chrysemys picta* FROM  
EASTERN TENNESSEE  
Measurements are in mm.

Coll. No.	Sex	Carapace		Plastron		Color of Plastron
		Length	Width	Length	Width of forelobe for forelobe	
RMJ-444	?	..	..	46	28	Immaculate yellow
RMJ-living	?	46	46	41	24	Immaculate yellow
RMJ-452	♂	95	73	87	45	Immaculate yellow
RMJ-453	♂	92	74	86	51	Immaculate yellow
CPP-2	♂	108	82	97	..	Immaculate yellow
CPP-1	♀	122	98	113	..	Immaculate yellow
RMJ-452-2	♀	142	114	132	67	Immaculate yellow
RMJ-214	♂	114	80	104	55	Yellow, with central dusky figure; 21 mm. at widest point
RMJ-214-2	♂	54	49	49	28	Yellow, with central dusky figure; 4.2 mm. at widest point
RMJ-452-3	♀	126	90	114	61	Yellow, with outline of central dusky figure; 30 mm. at widest point

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On the *cit.*: 214) RMJ-452 and the r slight alt laminae is acter. In than a re gradation indicated.

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specimens discussed in this paper have the dorsal stripe narrower than the stripes of the forelegs.

On the basis of key characters alone (Carr, *op. cit.*: 214) specimens RMJ-214, RMJ-214-2, and RMJ-452-3 would be identified as *C. p. marginata*, and the remaining specimens as *C. p. picta*, if the slight alternation of the seams of the carapace laminae is not interpreted as a *C. p. dorsalis* character. In the author's opinion, this a natural rather than a relict population of *C. p. picta*, with intergradation between it and *C. p. marginata*, at least, indicated.

The range of sizes of the carapace lengths is accepted as presumptive evidence that these individuals came from a naturally breeding population and were not transported to eastern Tennessee by human agency. *C. p. picta* could enter eastern Tennessee via the Powell, Clinch, Holston, French Broad-Nolichucky Rivers or over the Coosa River divide from northern Georgia. *C. p. marginata* could enter via the Powell, Clinch, or Holston Rivers or over the Cumberland drainage divide. More extensive collections and field investigations are necessary before the exact systematic status of the eastern Tennessee population of *Chrysemys* can be determined.

Specimens RMJ-214 are from Laurel Lake, Blount County; specimens RMJ-444, RMJ-453, and RMJ-living are from McMinn County; specimens RMJ-452 are from Rhea County.

I wish to thank Dr. Archie F. Carr, Department of Biology, University of Florida, and Dr. Fred R. Cagle, Department of Zoology, Tulane University, for criticizing this manuscript. My thanks also to Mr. Arthur Stupka, Great Smoky Mountains National Park, for permission to examine material in the Park collection.—RICHARD M. JOHNSON, Department of Biology, Tennessee Wesleyan College, Athens, Tennessee.

**NOTES ON THE BEHAVIOR OF THE LIZARD ANOLIS CAROLINENSIS.**—That *Anolis carolinensis* may actively protect its territory was suggested by observation on an individual at Tribby, Florida, in the summer of 1953.

As I was leaving my quarters (a house raised on pillars) and came onto the back steps, I saw a male anolis scamper along a wall and stop after moving about 5 feet. His original position was over a jar containing about a dozen swifts (*Sceloporus undulatus*) that I had collected the day before. After a few minutes the anolis turned around and faced the jar and began to bob and show his dewlap. Then by a series of short dashes he made his way along the wall to a point immediately above the jar. Between dashes he often stopped to bob and show his dewlap; a gesture seemingly directed toward the swifts in the jar and not me. At the

point on the wall over the jar, the anolis remained for about 10 minutes and carried on the bobbing and strutting action. Most of the time he seemed to be watching the jar, but occasionally he looked around.

After this period of display, the anolis approached to within a foot of my side, looked me over, and then dashed to my other side by going behind me. Following this, he went slowly across the wall of the house in a fashion that suggested a cat stalking its prey. The lizard continued this stalking gait, and then went between two boards at the base of the house.

In a few minutes he reappeared, this time making his way rapidly toward the opposite side of the house. Then by a series of short dashes he worked his way along a board for a distance of about 5 feet. In front of the anolis I caught sight of a skink (*Eumeces* sp.) resting on another and lower board. The skink dropped out of sight among some rocks, and the anolis scampered to that point and again displayed his dewlap and bobbed up and down. Finally he crawled into a crack above where the skink had been, and remained there until it began to rain. Here he seemed to be watching for the reappearance of the skink.

During the entire performance it seemed that the anolis might have been trying to hold or establish a territory.—FRED G. THOMPSON, Cleveland Museum of Natural History, Cleveland, Ohio.

**ADAPTATION TO FEEDING IN THE SNAKE *CONTIA TENUIS*.**—The biology of *Contia*, one of the less commonly collected snakes of the Pacific Coast region, has been little investigated. Recently Stickle (1951, *Herpetologica* 7: 126) called attention to the relatively long teeth present in *Contia*, and Darling (1947, *Herpetologica* 4: 28) recorded the presence of slugs in the stomachs of six of 23 specimens examined. The purpose of the present note is to correlate these observations.

*Contia* appears to be primarily a slug eater. Feeding upon both slugs and slug eggs has been observed in captivity, while insect larvae and pupae (mealworms and noctuid caterpillars) were not taken. The slender salamander (*Batrachoseps attenuatus*) was likewise ignored by *Contia* which I have kept captive, though Mr. William Woodin (*in litt.*) reports an instance of the disappearance of a *Batrachoseps* from a container which also held a *Contia*, the snake presumably having eaten the salamander. The long, recurved teeth of *Contia* seem to be a specialization for grasping and holding the slippery mollusks on which it feeds; they enable the snake to overcome a slug which, in the contracted state, has a diameter greater than that of the snake's head.

When the dentition of *Contia* is compared with

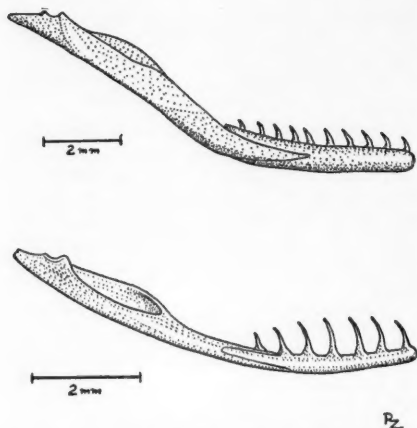


Fig. 1. Right maxilla of *Diadophis amabilis* (upper) and *Contia tenuis* (lower).

that of a more typical colubrid, such as *Diadophis amabilis* (Fig. 1), the extent of the specialization becomes obvious. *Diadophis amabilis* and *Contia tenuis* co-exist in the same habitat throughout much of their respective ranges and may even be found under the same piece of cover. *Diadophis*, wherever *Batrachoseps* occurs, feeds primarily on that salamander. So, despite their similarity in habitat and general body form and size, there is probably little competition for food between *Contia* and *Diadophis*, these snakes operating, in the Eltonian sense, in different ecologic niches.—RICHARD G. ZWEIFEL, Museum of Vertebrate Zoology, University of California, Berkeley, California.

**EGGS OF THE SALAMANDER AMBYSTOMA JEFFERSONIANUM IN THE CHICAGO AREA.**—Eggs of Jefferson's salamander, *Ambystoma jeffersonianum*, were vainly sought in a small vernal pond one early spring day in 1952. This pond had been sampled in most years since 1942 and was of interest in that the only salamander larvae ever collected from it were those of *A. jeffersonianum*. Other local ponds contain larvae of this form as well as those of *A. maculatum* and, occasionally, *A. tigrinum*. Since *Ambystoma* egg masses were clearly evident in other ponds on this occasion (a fraction of which were presumed to be egg masses of Jefferson's salamander), their apparent absence in this pond precipitated an intensive search. It is with some embarrassment that, at this late date, the observation is publicized that in the Chicago area Jefferson's salamander typically lays its eggs singly, in pairs, or in small groups attached to leaves and litter on the bottom of ponds.

Several days later, in early April, a survey was made of about fifty woodland ponds from which larvae or adults of *A. jeffersonianum* had been collected in the past. These ponds were distributed from Lake Bluff to west of Lake Forest and south along the Des Plaines River area to Palos Park, Illinois. This survey revealed that the egg-laying habits of Jefferson's salamander throughout this area are identical with those described above. Also, in the early spring of 1953 a specimen was removed to a laboratory tank where its possibly modified oviposition occurred. Eggs were deposited on the glass bottom or on litter as the animal walked about; there appeared to be no selection for egg attachment sites. Apparently the widespread coverage of pond bottoms with eggs may be accomplished in the field in a similar way.

Previously we had been accustomed to assume that in the Chicago area eggs of *A. jeffersonianum* are laid in masses, containing from 7 to 40 eggs, with 16 as an approximate average, as obtains in the east (Bishop, 1943, Handbook of Salamanders: 135; Pope, 1944, Amphibians and Reptiles of the Chicago Area: 32). Similarly, it was also assumed that the eggs of this form are attached to upright sticks or stems just below the surface of the pond. Apparently neither assumption is valid for this area.—W. T. STILLE, Saunders Road, Lake Forest, Illinois.

**SUBSPECIFIC IDENTITY OF *CROTALUS HORRIDUS* IN WASHINGTON COUNTY, MISSOURI.**—In late July of 1953, I had the opportunity to examine two freshly killed rattlesnakes from the southwestern part of Washington County, Missouri. In view of the fact that these snakes will probably not be available for future taxonomic studies, I have considered it best to place on record my notes concerning them. The rarity of *Crotalus* in eastern Missouri has prompted this action.

Both specimens have the following characteristics in common: 26–25–21 dorsal scale rows; poorly developed postocular stripes; ground color pale grey with strongly contrasting crossbands. The smaller of the two, a male, was killed in T38N, R1E, Sec. 18. Its tail length was 89 mm., total length 1181 mm. It had 24 caudals and 168 ventrals. The crossbands were decidedly chevron shaped; the anterior lateral blotches had light centers. There was a well defined mid-dorsal stripe throughout the length of the body. The larger specimen, a female, was killed in T37N, R1W, Sec. 17. The tail length was 92 mm., total length 1281 mm. It had 27 caudals and 166 ventrals. The crossbands were not chevron shaped; the anterior lateral blotches were without decidedly light centers. A reddish-brown mid-dorsal stripe was present but it was faintly indicated.

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Unless future work in this locale proves otherwise, I believe it best to recognize these snakes as *Crotalus h. horridus* × *C. h. atricaudatus*.

Gloyd (1940, Special Publ. Chicago Acad. Sci., No. 4) reported specimens intermediate between *horridus* and *atricaudatus* from southern Illinois and southeastern Missouri. He thought it possible that intergrades would be discovered in additional localities around the edge of the Ozark Plateau. The

specimens described herein tend to substantiate his views.

I am indebted to Bill Fowler, the Jefferson County Conservation Agent, for obtaining the exact localities in which the snakes were killed. Both snakes at the present time are in the possession of Chester Negin of Potosi, Missouri.—CHARLES W. MYERS, 4742 Leduc, St. Louis 13, Missouri.

## EDITORIAL NOTES AND NEWS

### FINANCIAL REPORT FOR CALENDAR YEAR 1953

By Coleman J. Goin, Treasurer

#### CHECKING ACCOUNT

Balance on hand, Citizen's Bank of Gainesville, Jan. 1, 1953.....	\$2,216.33
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#### Receipts

Received from retiring treasurer.....	2,917.62
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#### Memberships received

Current dues for 1953.....	1,838.24
Back dues for 1952 and before.....	24.50
Advance dues for 1954 and beyond.....	3,395.92

5,258.66

#### Subscriptions

Current, for 1953.....	767.10
Back, for 1952 and before.....	42.00
Advance, for 1954 and beyond.....	1,279.40

2,088.50

Back numbers of COPEIA sold (from Publications Secretary).....	1,011.57
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Interest, STROYE Fund bonds.....	75.00
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Interest, Endowment bonds.....	100.00
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#### Contributions

CARL HUBBS (Prizes, ich. pap., West. Div.).....	40.00
L. M. KLAUBER (Prizes, herp. pap., West Div.).....	40.00
From members (Towards publications costs).....	45.00

125.00

Charges for use of mailing list.....	11.93
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Refund from New York Local Committee.....	40.86
Postage refund from Henry Hudson Hotel.....	20.14
Total.....	\$13,865.61

## Expenditures and disbursements

## Cost of publication of COPEIA

COPEIA 1952, No. 4.....	\$1,803.02
COPEIA 1953, No. 1.....	1,405.28
COPEIA 1953, No. 2.....	1,125.87
COPEIA 1953, No. 3.....	1,427.50
COPEIA 1953, No. 4.....	1,481.51

7,243.18

Printing.....	449.61
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## Stenographic services

Gainesville.....	192.41
Huntington.....	32.00

224.41

## Postage and incidentals

Secretary, Gainesville.....	270.14
Editors, Ann Arbor.....	50.00

320.14

## Travel expenses

Secretary, New York Meetings.....	151.69
J. C. DICKINSON, A.I.B.S. Meetings.....	38.71

190.40

## Contributions

Remittance of 40 pounds to Zoological Society to assist in publication of "Zoological Record".....	113.60
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Dues, American Institute of Biological Sciences.....	764.50
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## Prizes awarded at Annual and Western Division meetings

K. S. NORRIS (Western Division).....	25.00
WM. J. RIEMER (Western Division).....	25.00
NORMAN J. WILIMOVSKY.....	25.00
J. M. SAVAGE.....	25.00
GEORGE C. WILLIAMS (Western Division).....	15.00
BAYARD H. BRATTSTROM (Western Division).....	15.00
RICHARD HIGHTON.....	15.00

145.00

Final Payment on Herpetological Check List.....	356.78
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Mailing cartons for Check List.....	5.85
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Purchase of back numbers for Publications Secretary.....	57.00
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Bank charges.....	2.24
Total expenditures.....	9,872.71
Balance on hand, Citizen's Bank, Dec. 31, 1953.....	3,992.90
Total.....	\$13,865.61

## ENDOWMENT FUND

Balance on hand, First Federal Savings and Loan Association, Jan. 1, 1953.....	\$175.00
Received from members for life memberships.....	450.00
Received from sale of Check List.....	97.50
Interest.....	10.65
Balance on hand, First Federal Savings and Loan Association, Dec. 31, 1953.....	\$733.15

## REVOLVING RESEARCH FUND

Balance on hand, Florida Bank of Gainesville, Jan. 1, 1953.....	\$620.25
Grant to MESSRS. WILLIAM K. RIEMER and RICHARD G. ZWEIFEL.....	200.00
Leaving Balance on hand, Florida Bank of Gainesville, Dec. 31, 1953.....	\$420.25

# Natural History Museum, Stan- ford University

**P**ERMANENT headquarters for the GEORGE VANDERBILT FOUNDATION, a newly formed scientific research organization, have been established at the Stanford Natural History Museum. Announcement of the research center, which is now engaged primarily in fish studies, was made on June 22 by Stanford President WALLACE STERLING, who added that ichthyologists of both the University and the Foundation expect to benefit greatly from their collaboration in research work.

Several expeditions for collecting Pacific Ocean fishes have been sponsored in the last three years by GEORGE VANDERBILT of Honolulu, some of them jointly with government agencies. Plans for the Foundation were laid on the first expedition to Polynesia by VANDERBILT, himself an accomplished scientist and explorer, and three companions—VERNON E. BROCK, DR. EARL S. HERALD, and DR. ROBERT R. HARRY. The initial task of the Foundation, the four decided, should be to gather urgently needed information about the fishes of the South Pacific and make it available through publication. As now established, the Foundation's trustees are VANDERBILT, HERALD, and HARRY. DR. HARRY will also serve as director at the Stanford campus headquarters. In addition the Foundation has offices in Philadelphia and Honolulu.

Another current educational project of the Foundation is a Honolulu television program, "The

Hawaiian Picture," for which VANDERBILT is both producer and narrator. It is sponsored by the Bishop Museum of Honolulu. The Hawaiian TV program is modeled after the California Academy of Sciences' prize-winning "Science in Action" telecasts, which originate in San Francisco with DR. HERALD as host-scientist. Kinescopes of "Science in Action" are telecast in Honolulu also, just following the airing of "The Hawaiian Picture."

DR. JAY M. SAVAGE, who received his PhD in August, spent the summer reorganizing the herpetological collections at the Academy of Natural Sciences of Philadelphia.

Investigations on arctic Alaskan waters by NORMAN J. WILIMOVSKY were assured for the fourth consecutive year through receipt of grants from the Arctic Institute of North America and an extension of an Office of Naval Research contract. Research has been directed toward a study of the fish fauna and basic biological productivity. Base of operations again were the Navy's Arctic Research Laboratory, Point Barrow, Alaska. MR. WILIMOVSKY was assisted in the field by H. ADAIR FEHLMANN and DANIEL M. COHEN, also of Stanford University, both of whom have had previous experience in this region of the arctic. This year, investigations centered around studies on the deeper waters (ice conditions permitting) and on the possible nutritive effect of ice-melt waters on the productivity of the ocean.

DR. DONALD E. WOHLSCHLAG and his assistant,

WARREN G. FREIHOFER, spent the summer in the Alaskan Arctic studying the nature of arctic coastal and freshwater salmonoid fish populations. Experiments were undertaken to determine the existence of metabolic differences between the "fat" lake forms of *Leucichthys sardinella* and the "skinny" estuary populations. Extensive collections were made from several lake-stream-estuary systems for comparative growth and morphological analyses. The research was sponsored by the Arctic Institute of North America with the base of field operations at Point Barrow, Alaska.

#### News Notes

**T**HE origin of snakes (1951, Biol. Rev. Cambridge Philosoph. Soc., 26 (2): 193-237), by A. D'A. Bellairs and Garth Underwood, has been reprinted and may be obtained at cost plus mailing charges. Postpaid prices of this 44-page article are as follows: 1 copy \$0.35; 2, \$0.67; 3, \$0.95; 4, \$1.23; 5, \$1.55; 6, \$1.83; 7, \$2.11; 8, \$2.39; 9, \$2.67; 10, \$2.99. Since these reprints are being sold at cost, payment must accompany each order; billings can not be made. Orders should be

sent to NORMAN HARTWEG, 2506 Geddes Avenue, Ann Arbor, Michigan.

In continuation of his studies of the fishes of the Western Indian Ocean, PROFESSOR J. L. B. SMITH of Rhodes University, Grahamstown, South Africa, has left on an expedition designed to cover parts of the Kenya coast but mainly the islands north of Madagascar. The main base of the expedition will be the Seychelles group and from there they will operate over an extensive area in small vessels working at the numerous reefs and islands that lie just south of the Equator. It is PROFESSOR SMITH's aim to produce a comprehensive work on the fishes of the Western Indian Ocean, which have been very largely unknown. Among other objects is the preparation of a book on the fishes of East Africa on the lines of his well known *Sea Fishes of Southern Africa*, to which it is intended to be a companion volume. PROFESSOR SMITH will be accompanied by his wife, who has become equally well known for her excellent illustrations, and who is an experienced and able field worker and collector of fishes. They expect to continue their operations until early next year.

### Omissions from the Sixth Edition of the *Check List of North American Amphibians and Reptiles*

The stated deadline for consideration of published material in the sixth edition of the *Check List of North American Amphibians and Reptiles* was December 31, 1951. The final manuscript was delivered to the University of Chicago Press on November 1, 1952, and the first printed copies were available July 23, 1953. Through the efforts of D. Dwight Davis, the chairman of the check-list committee, two unbound copies reached my hands on that date while Mrs. Schmidt and I were waiting for the train to take us to New York en route to Europe. In the course of seeing the manuscript through the press, I freely corrected and amended the proof; but it could be discerned from the number of additions required that there might well be other omissions that failed to come to my attention.

Among the numerous corrections, additions, and criticisms received from my colleagues since the distribution of the *Check List*, there are four outright omissions of forms regarded as valid, and a much larger number of minor defects than I had anticipated, though perhaps no larger than I had feared. I am indebted especially to Charles M. Bogert, Joseph A. Tihen, Bryce Brown, Robert H. Ahrenfeldt, and M. B. Mittleman for corrections and additions. I wish to thank also the large number of other colleagues who have sent lists of printer's errors, lapses of my own, and additions, and who have offered corrections and additions to the statements of range. They may rest assured that, should there be a seventh edition of the *Check List*, their suggestions will contribute notably to improvements over the sixth. There are already extensive additions and revisions in the 1952 and 1953 literature. It was disconcerting to find that my check of type-localities failed during proof-reading. I have listed the omitted ones for those who may wish to annotate their copies.

#### Subspecies omitted from the *Check List*

##### *Gerrhonotus coeruleus utahensis* Woodbury

*Gerrhonotus coeruleus utahensis* Woodbury, 1945, Proc. Biol. Soc. Washington, 58: 6, pl. 1.—Siak Valley, south of Alton, about 20 miles north of Kanaab, Kane County, Utah (about 6500 feet alt.).

Range.—Southern Utah.

Common name.—Utah alligator lizard.

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**Gerrhonotus kingi nobilis** Baird and Girard

*Elgaria nobilis* Baird and Girard, 1852, Proc. Acad. Nat. Sci. Phila., 6: 129.—Fort Webster, copper mines of the Gila (Santa Rita del Cobre), New Mexico.

*Elgaria kingii nobilis* Tihen, 1948, Trans. Kansas Acad. Sci., 51: 300.

**Range.**—Central and southern Arizona, and southern New Mexico, intergrading with *kingi kingi* in northern Chihuahua.

**Common name.**—Arizona alligator lizard.

**Thamnophis sirtalis annectens** Brown

*Thamnophis sirtalis annectens* Brown, 1950, Check list rept. amphib. Texas, p. 203.—Boggy Creek, one mile east of Austin, Travis County, Texas.

**Range.**—Central and north central Texas, probably also southern Oklahoma.

**Common name.**—Texas garter snake.

**Salvadora hexalepis mojaviensis** Bogert

*Salvadora hexalepis mojaviensis* Bogert, 1945, Amer. Mus. Novitates, 1285: 6, fig. 5-9.—Deadman Point, 11.5 miles southeast of Victorville, San Bernardino County, California.

**Range.**—Principally the Mojave Desert; from Washington County, Utah, and Washoe County, Nevada, southeast to San Bernardino County, California and Coconino County, Arizona.

**Common name.**—Mojave patch-nosed snake.

Synonyms omitted from the *Check List*

*Anniella texana* Boulenger, 1887, Ann. Mag. Nat. Hist., (51, 20: 50).—El Paso, Texas (in error); designated as San Diego, San Diego County, California.

This is plainly a synonym of *Anniella pulchra pulchra*.

*Coluber Dumfriensiensis* Sowerby, 1804, The British Miscellany, p. 5 (pl. 3).—Dumfriesshire, Scotland (in error); designated as Charleston, South Carolina.

Dr. R. H. Ahrenfeldt, of Binsted Place, near Alton, Hampshire, England, wrote me in 1953 as to the proper allocation of this name, and as the British Miscellany was not available in Chicago, kindly sent me a photographic copy of the plate illustrating it. Boulenger referred *dumfriensiensis* to his broad species, *Coronella dolia*. Inspection of the plate in question makes the reference to *Cemophora coccinea* much the most satisfactory disposal of this name.

Type localities omitted from the *Check List*

- p. 31 *Desmognathus monticola jeffersoni* Hoffman  
Type locality.—Saddle Hollow on Jarman's Mountain, 2 miles west of Crozet, Albamarle County, Virginia. (The reference should read volume 67.)
- p. 97 *Malaclemys terrapin littoralis* Hay  
Type locality.—Rockport, Texas.
- p. 110 *Trionyx ferox hartwegi* Conant and Goin  
Type locality.—Wichita, Sedgewick County, Kansas.
- p. 140 *Gerrhonotus liocephalus* Wiegmann  
Type locality.—Mexico.
- p. 140 *Gerrhonotus liocephalus infernalis* Baird  
Type locality.—Devil's River, Texas.
- p. 148 *Plistodon striatus* Abbott  
Type locality.—New Jersey (reference not seen).
- p. 156 *Leptotyphlops humilis utahensis* Tanner  
Type locality.—Saint George, Washington County, Utah. (The reference should read volume 15, p. 149.)
- p. 166 *Storeria occipitomaculata* Storer  
Type locality.—Amherst, Massachusetts.



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